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Acoustic assessment and distribution of anchovy and sardine in ICES Subdivision IXa South during the *ECOCADIZ 2015-07* Spanish survey (July-August 2015) with notes on the distribution of other pelagic species.

By

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ABSTRACT

The present working document summarises a part of the main results obtained from the Spanish (pelagic ecosystem-) acoustic survey conducted by IEO between 28th July and 10th August 2015 in the Portuguese and Spanish shelf waters (20-200 m isobaths) off the Gulf of Cadiz onboard the R/V *Miguel Oliver*. The 21 foreseen acoustic transects were sampled. A total of 19 valid fishing hauls were carried out for echo-trace ground-truthing purposes. CUFES sampling (117 stations) was carried during the survey in order to describe the extension of the anchovy spawning area. A census of top predator species was also carried out along the sampled acoustic transects. This working document only provides abundance and biomass estimates for anchovy and sardine which are presented without age structure. The distribution of all the mid-sized and small pelagic fish species susceptible of being acoustically assessed is also shown from the mapping of their back-scattering energies. Sardine was the most frequent species in the fishing hauls, followed by horse mackerel, chub mackerel, anchovy and mackerel. However, the most abundant species in these hauls was anchovy, followed at quite a distance by blue jack mackerel, sardine, horse mackerel and chub mackerel. As usual, the bulk of the anchovy population was concentrated in the central part of the surveyed area, with the smallest anchovies mainly occurring in the surroundings of the Guadiana and Guadalquivir river mouths and Bay of Cadiz, and larger/older anchovies occurring in the westernmost waters. The total biomass estimated for anchovy, 21.3 kt (2 506 million fish), was slightly below the historical average, but it still in the range of population levels featuring to a recovered population. The comparison of these estimates with their spring counterparts from the PELAGO survey evidences almost identical values for the Portuguese waters, whereas the ECOCADIZ survey estimated in summer at about 1000 million and 11800 t less of anchovy in the Spanish waters. Such differences might be attributable to a possible overestimation of the acoustic energy attributed to anchovy in the Spanish waters of the Gulf by the PELAGO survey because of the difficulties in the discrimination of anchovy echoes in this area from a dense plankton layer where the species was embedded. Sardine was widely distributed all over the surveyed area but in the easternmost waters closer to the Strait of Gibraltar and showed two main nuclei of density: the coastal waters of the central part of the Gulf, and the inner-mid shelf waters between Cape San Vicente and Cape Santa Maria. Sardine yielded a total of 23.5 kt (883 million fish), population levels which have showed some recovery from the lowest historical values recorded in the two previous years but still below the historical average. In contrast to the abovementioned for anchovy, ECOCADIZ survey estimated in summer 4 fold more sardine in Spanish waters than PELAGO survey in spring, with the juvenile fraction being the dominant in both seasons. The progressive incorporation (recruitment) of juveniles coming from successive spawning events may be the reason for such seasonal differences.

INTRODUCTION

ECOCADIZ surveys constitute a series of yearly acoustic surveys conducted by IEO in the Subdivision IXa South (Algarve and Gulf of Cadiz, between 20 – 200 m depth) under the "pelagic ecosystem survey" approach onboard R/V *Cornide de Saavedra* (until 2013, since 2014 on onboard R/V *Miguel Oliver*). This series started in 2004 with the *BOCADEVA 0604* pilot acoustic - anchovy DEPM survey. The following surveys within this new series (named *ECOCADIZ* since 2006 onwards) are planned to be routinely performed on a yearly basis, although the series, because of the available ship time, has shown some gaps in those years coinciding with the conduction of the triennial anchovy DEPM survey (the true *BOCADEVA* series, which first survey started in 2005).

Results from the *ECOCADIZ* series are routinely reported to ICES Expert Groups on both stock assessment (formerly in WGMHSA, WGANC, WGANSA, at present in WGHANSA) and acoustic and egg surveys on anchovy and sardine (WGACEGG).

The present Working Document advances some results from the *ECOCADIZ 2015-07* survey. These results will only refer to the acoustic estimates (not age-structured) and spatial distribution of anchovy and sardine and to inferences on the spatial distribution of other pelagic species from the distribution of the acoustic energy attributed to each of these species.

MATERIAL AND METHODS

The *ECOCADIZ 2015-07* survey was carried out between 28th July and 10th August 2015 onboard the Spanish R/V *Miguel Oliver* covering a survey area comprising the waters of the Gulf of Cadiz, both Spanish and Portuguese, between the 20 m and 200 m isobaths. The survey design consisted in a systematic parallel grid with tracks equally spaced by 8 nm, normal to the shoreline (**Figure 1**).

Echo-integration was carried out with a *Simrad™ EK60* echo sounder working in the multi-frequency fashion (18, 38, 70, 120, 200 kHz). Average survey speed was about 10 knots and the acoustic signals were integrated over 1-nm intervals (ESDU). Raw acoustic data were stored for further post-processing using *Myriax Software Echoview™* software package (by *Myriax Software Pty. Ltd.,* ex *SonarData Pty. Ltd.*). Acoustic equipment was previously calibrated during the *MEDIAS 07 2015* acoustic survey, a survey conducted in the Spanish Mediterranean waters just before the *ECOCADIZ* one, following the standard procedures (Demer *et al*., 2015).

Survey execution and abundance estimation followed the methodologies firstly adopted by the ICES *Planning Group for Acoustic Surveys in ICES Sub-Areas VIII and IX* (ICES, 1998) and the recommendations given more recently by the *Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES areas VIII and IX* (WGACEGG; ICES, 2006a,b).

Fishing stations for echo-trace ground-truthing were opportunistic, according to the echogram information, and they were carried out using a ca. 16 m-mean vertical opening pelagic trawl (*Tuneado* gear) at an average speed of 4 knots. Gear performance and geometry during the effective fishing was monitored with *Simrad™ Mesotech FS20/25* trawl sonar. Trawl sonar data from each haul were recorded and stored for further analyses.

Ground-truthing haul samples provided biological data on species and they were also used to identify fish species and to allocate the back-scattering values into fish species according to the proportions found at the fishing stations (Nakken and Dommasnes, 1975).

Length frequency distributions (LFD) by 0.5-cm class were obtained for all the fish species in trawl samples (either from the total catch or from a representative random sample of 100-200 fish). Only those LFDs based on a minimum of 30 individuals and showing a normal distribution were considered for the purpose of the acoustic assessment.

Individual biological sampling (length, weight, sex, maturity stage, stomach fullness, and mesenteric fat content) was performed in each haul for anchovy, sardine (in both species with otolith extraction and with additional preservation of gonads in anchovy mature females), mackerel and horse-mackerel species, and bogue.

The following TS/length relationship table was used for acoustic estimation of assessed species (recent IEO standards after ICES, 1998; and recommendations by ICES, 2006a,b):

Species	b_{20}
Sardine (*Sardina pilchardus*)	-72.6
Round sardinella (*Sardinella aurita*)	-72.6
Anchovy (*Engraulis encrasicolus*)	-72.6
Chub mackerel (*Scomber japonicus*)	-68.7
Mackerel (*S. scombrus*)	-84.9
Horse mackerel (*Trachurus trachurus*)	-68.7
Mediterranean horse-mackerel (*T. mediterraneus*)	-68.7
Blue jack mackerel (*T. picturatus*)	-68.7
Bogue (*Boops boops*)	-67.0

The *PESMA 2010* software (J. Miquel, unpublished) has got implemented the needed procedures and routines for the acoustic assessment following the above approach.

A *Continuous Underway Fish Egg Sampler* (CUFES), a *Sea-bird Electronics™ SBE 21 SEACAT* thermosalinograph and a *Turner™ 10 AU 005 CE Field* fluorometer were used during the acoustic tracking to continuously monitor the anchovy egg abundance and to collect some hydrographical variables (sub-surface sea temperature, salinity, and *in vivo* fluorescence; **Figure 2**). Vertical profiles of hydrographical variables were also recorded by night from 157 CTD casts by using *Sea-bird Electronics™ SBE 911+ SEACAT* (with coupled *Datasonics* altimeter, *SBE 43* oximeter, *WetLabs ECO-FL-NTU* fluorimeter and *WetLabs C-Star 25 cm* transmissometer sensors) and *LADCP T-RDI WHS* 300 kHz profilers (**Figure 3**). *VMADCP RDI 150 kHz* records were also continuously recorded by night between CTD stations. Information on presence and abundance of sea birds, turtles and mammals was also recorded during the acoustic sampling by one onboard observer.

ECOCADIZ 2015-07 was also utilized this year as an observational platform for the IFAPA (Instituto de Investigación y Formación Agraria y Pesquera)/IEO research project entitled *Ecology of the early stages of the anchovy life-cycle: the role of the coupled Guadalquivir estuary-coastal zone of influence in the species' recruitment process (ECOBOGUE)*. Thus, 4 *Bongo 90* coastal stations were carried out at sunset in the surroundings of the Guadiana (2 stations) and Guadalquivir (2 stations) river mouths to collect anchovy larvae for genetics studies (**Figure 2**).

RESULTS

Acoustic sampling

The acoustic sampling started on 29th July in the coastal end of the transect RA01 and finalized on 07th August in the oceanic end of the transect RA21 (**Table 1, Figure 1**). Transects were acoustically sampled in the E-W direction. The whole 21-transect sampling grid was sampled. The acoustic sampling usually started at 06:00 UTC although this time might vary depending on the duration of the works related with the hydrographic sampling. The foreseen start of transects RA14 and RA15 by the coastal end had to be displaced to deeper waters in order to avoid the occurrence of open-sea fish farming/fattening cages.

Groundtruthing hauls

Twenty two (22) fishing operations, with 19 of them being considered as valid ones according to a correct gear performance and resulting catches, were carried out (**Table 2**, **Figure 4**). Null hauls were actually composed by 2 initial trials for checking the behaviour and configuration of the available fishing gears (fishing stations # 01 and 02) and one fishing haul (fishing station # 17) carried out in pure pelagic fashion which finally resulted unsuccessful.

As usual in previous surveys, some fishing hauls were attempted by fishing over an isobath crossing the acoustic transect as close as possible to the depths where the fishing situation of interest was detected over that transect. In this way the mixing of different size compositions (*i.e*., bi-, multi-modality of length frequency distributions) was avoided as well as a direct interaction with fixed gears. The mixing of sizes is more probable close to nursery-recruitment areas and in regions with a very narrow continental shelf. Given that all of these situations were not very uncommon in the sampled area, 42% of valid hauls (8 hauls) were conducted over isobath.

Because of many echo-traces usually occurred close to the bottom, all the pelagic hauls were carried out like a bottom-trawl haul, with the ground rope working over or very close to the bottom. According to the above, the sampled depth range in the valid hauls oscillated between 38-172 m.

During the survey were captured 4 Chondrichthyan, 39 Osteichthyes, 4 Cephalopod, 8 Crustacean, 5 Echinoderm, 2 Polychaeta, 1 Sipunculidea, 2 Porifera, 4 Cnidarian and 1 Thaliacean species. The percentage of occurrence of the more frequent species in the trawl hauls is shown in the enclosed text table below (see also **Figure 5**. The pelagic ichthyofauna was the most frequently captured species set and the one composing the bulk of the overall yields of the catches. Within this pelagic fish species set, sardine was the most frequent captured species in the valid hauls (18 hauls, 95% presence index) followed by horse mackerel, chub mackerel, anchovy and mackerel (with relative occurrences between 70-80%). Bogue and blue jack mackerel showed a medium relative frequency of occurrence (ca. 50-60%), whereas Mediterranean horse mackerel showed a low occurrence in the whole surveyed area (21%).

For the purposes of the acoustic assessment, anchovy, sardine, mackerel species, horse & jack mackerel species, and bogue were initially considered as the survey target species. All of the invertebrates, and both bentho-pelagic (*e.g.*, manta rays) and benthic fish species (*e.g*., flatfish, gurnards, etc.) were excluded from the computation of the total catches in weight and in number from those fishing stations where they occurred. Catches of the remaining non-target species were included in an operational category termed as "*Others*".

According to the above premises, during the survey were captured a total of 10.5 tonnes and 307 thousand fish (**Table 3**). 28% of this fished biomass corresponded to blue-jack mackerel, 19% to sardine, 18% to chub mackerel, anchovy and horse mackerel 13% each, 3% to Mediterranean horse mackerel, and

contributions lower than 1% by the remaining species. However, the most abundant species in ground-truthing trawl hauls was anchovy (51%) followed by a long distance by blue jack mackerel (17%), sardine (15%), horse mackerel (9%) and chub mackerel (6%).

Species	# of fishing stations	Occurrence (%)	Total weight (kg)	Total number
Merluccius merluccius	19	100	169,218	2745
Sardina pilchardus	18	95	1956,451	45055
Loligo spp	17	89	5,409	1809
Trachurus trachurus	16	84	1399,624	26394
Scomber colias	15	79	1914,333	17822
Engraulis encrasicolus	15	79	1401,372	155790
Scomber scombrus	14	74	38,035	183
Boops boops	11	58	22,575	188
Trachurus picturatus	10	53	2956,827	50765
Alosa fallax	8	42	3,519	14
Spondyliosoma cantharus	8	42	14,108	78
Diplodus annularis	6	32	2,638	52
Eledone moschata	6	32	1,442	10
Aphia minuta	6	32	0,346	164
Pagellus erythrinus	6	32	94,348	568
Pagellus bellottii bellottii	5	26	7,978	56
Diplodus bellottii	5	26	3,668	67
Chelidonichthys lucerna	5	26	0,426	5
Diplodus vulgaris	4	21	13,038	89
Trachurus mediterraneus	4	21	325,372	1910

The species composition, in terms of percentages in number, in each valid fish station is shown in **Figure 5**. A first impression of the distribution pattern of the main species may be derived from the above figure. Thus, anchovy showed a relatively wide distribution over the surveyed area, although the highest yields were recorded in the Spanish waters. The size composition of anchovy catches confirms the usual pattern exhibited by the species in the area during the spawning season, with the largest fish being distributed in the westernmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz. This summer small anchovies were also recorded in the coastal area close to the Guadiana river mouth (**Figure 6**). Sardine was even more frequent and widely distributed than anchovy, with the highest yields being mainly recorded in the westernmost waters of the surveyed area. Juvenile sardines were almost exclusively captured in the shallowest hauls conducted in front of the Guadiana and Guadalquivir river mouths and the Bay of Cadiz (**Figure 7**). Mackerel, chub mackerel, horse mackerel, blue jack mackerel and bogue, although they occurred in a great part of the study area, only showed relatively high yields in the Portuguese waters. Mediterranean horse mackerel was restricted to the easternmost Spanish waters.

Back-scattering energy attributed to the "pelagic assemblage" and individual species

A total of 315 nmi (ESDU) from 21 transects has been acoustically sampled by echo-integration for assessment purposes. From this total, 207 nmi (11 transects) were sampled in Spanish waters, and 108 nmi (10 transects) in the Portuguese waters. The enclosed text table below provides the nautical area-scattering coefficients attributed to each of the selected target species and for the whole "pelagic fish assemblage".

$S_{A\,(m^2\,nmi^{-2})}$	Total spp.	Anchovy	Sardine	Mackerel	Chub mack.	Horse mack.	Medit. h-mack.	Blue jack-mack.	Bogue	Blue whiting	Boarfish
Total Area	104460	34311	15772	19	23790	10073	8354	10636	562	942	1
%	100	32,8	15,1	0,02	22,8	9,6	8	10,2	0,5	0,9	0
Portugal	56412	2355	8744	1	23650	9719	0	10546	454	942	1
%	54,0	6,9	55,4	6,7	99,4	96,5	0,0	99,2	80,8	100,0	100,0
Spain	48048	31956	7028	18	140	354	8354	90	108	0	0
%	46,0	93,1	44,6	93,3	0,6	3,5	100,0	0,8	19,2	0,0	0,0

For this "pelagic fish assemblage" has been estimated a total of 104 460 m^2 nmi^{-2}. Portuguese waters accounted for 54% of this total back-scattering energy and the Spanish waters the remaining 46%. However, given that the Portuguese sampled ESDUs were almost the half of the Spanish ones, the (weighted-) relative importance of the Portuguese area (*i.e.*, its density of "pelagic fish") is actually much higher. The mapping of the total back-scattering energy is shown in **Figure 8**. By species, anchovy (33%), chub mackerel (23%) and sardine (15%) were the most important species in terms of their contributions to the total back-scattering energy. Blue jack mackerel and Horse mackerel were the following species in importance with 10% each. Mediterranean horse mackerel only contributed with 8%, followed by negligible energetic contributions by mackerel, bogue, boarfish (*Capros aper*) and blue whiting (*Micromesistius poutassou*). Round sardinella was not recorded during the survey.

Some inferences on the species' distribution may be carried out from regional contributions to the total energy attributed to each species: Mediterranean horse mackerel, mackerel and anchovy seemed to show greater densities in the Spanish waters, whereas blue whiting, boarfish, chub mackerel, blue jack mackerel, horse mackerel, and bogue could be considered as typically "Portuguese species" in this survey.

According to the resulting values of integrated acoustic energy, the species acoustically assessed in the present survey finally were anchovy, sardine, mackerel, chub mackerel, blue jack mackerel, horse mackerel, Mediterranean horse mackerel and bogue. For the time being the only available acoustic estimates of abundance and biomass are the ones for anchovy and sardine. Furthermore, these estimates are not still presented with age-structure. For the remaining species only the spatial distribution of NASCs will be shown in the present WD.

Spatial distribution and abundance/biomass estimates

Anchovy

Parameters of the survey's length-weight relationship for anchovy are given in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 9**. The estimated abundance and biomass by size class are given in **Table 5** and **Figure 10**.

Anchovy avoided the easternmost waters of the Gulf. The bulk of the population was mainly distributed all over the shelf between the Guadiana river mouth and Bay of Cadiz, especially over the outer shelf waters of the central part of the Gulf, between the Guadiana river mouth and Matalascañas. A secondary nucleus of anchovy density was recorded in the western Portuguese Algarve, between Cape San Vicente and Albufeira, with the species being quite scarce in the surroundings of the Cape of Santa Maria (**Figure 9**).

The size class range of the assessed population varied between the 6.5 and 17 cm size classes, with two modal classes at 8.0 and 10.5 cm. The size composition of anchovy by coherent post-strata confirms the

usual pattern exhibited by the species in the area during the spawning season, with the largest fish being distributed in the westernmost waters and the smallest ones concentrated in the surroundings of the Guadalquivir river mouth and adjacent shallow waters, including those ones in front of the Bay of Cadiz (**Table 5**, **Figures 9** and **10**, see also **Figure 6**). This summer small anchovies were also recorded in the coastal area close to the Guadiana river mouth. As it has been happening in the last years, during the 2015 survey some recruitment has also been recorded, probably as a consequence of the delayed survey dates. This fact seems to have been much more evident this summer than in previous years because the markedly low mean length and weight estimated for the whole estimated population (106 mm; 8.0 g), the lowest record for both variables in the whole series.

Ten coherent post-strata have been differentiated according to the S_A value distribution and the size composition in the fishing stations. The acoustic estimates by homogeneous post-stratum and total area are shown in **Table 5** and **Figure 10**. Overall acoustic estimates in summer 2015 were of 2674 million fish and 21305 tonnes. By geographical strata, the Spanish waters yielded 93.7% (2506 million) and 90% (19168 t) of the total estimated abundance and biomass in the Gulf confirming the importance of these waters in the species' distribution. The estimates for the Portuguese waters were 168 million and 2137 t.

The Gulf of Cadiz anchovy egg distribution from CUFES sampling is shown in **Figure 11**. Anchovy egg distribution in summer 2015 resembled the abovementioned distribution for adult fish, with higher egg densities being mainly recorded in the middle-outer shelf waters located between the Guadiana and Tinto-Odiel river mouths. The highest egg density (121 eggs m^{-3}) was recorded in one station at a mean depth of 80.3 m located in the westernmost Spanish transect.

Sardine

Parameters of the survey's size-weight relationship for sardine are shown in **Table 4**. The back-scattering energy attributed to this species and the coherent strata considered for the acoustic estimation are shown in **Figure 12**. Estimated abundance and biomass by size class are given in **Table 6** and **Figure 13**.

Excepting the easternmost waters closer to the Strait of Gibraltar, where the species was absent, sardine was widely distributed all over the remaining surveyed area, preferably over the inner shelf, with the highest densities being recorded in two distinct zones: the coastal waters in front of the area comprised between Matalascañas and Chipiona, in the Spanish waters, and the inner-mid shelf waters between Cape San Vicente and Cape Santa Maria, in the Portuguese waters (**Figure 12**).

Sizes of the assessed population ranged between 7.5 and 22.5 cm size classes. The length frequency distribution of the population was clearly bimodal, with one main mode at 10.5 cm size class and a secondary one at 20.0 cm (**Table 6**; **Figure 13**). The 2015 summer estimate of mean size (135 mm) is the lowest one within the series. This fact might be explained by the dominance of the juvenile fraction in the estimated population (main mode at 10.5 cm), which was mainly located in relatively shallow waters in front of the Guadiana and Guadalquivir river mouths and the Bay of Cadiz (**Table 6**, **Figure 13,** see also **Figure 7**). However, such a decrease in mean size is not coupled with a similar decreasing trend in the mean weight (26.6 g), which was even somewhat higher than the historical average. It could be probable that the contribution in biomass of the adult fraction in the assessed population (around at a secondary modal size class at 20 cm) is enough to compensate the greater relative contribution of juveniles.

Nine size-based homogeneous sectors were delimited for the acoustic assessment. The estimates of Gulf of Cadiz sardine abundance and biomass in summer 2015 were 883 million fish and 23460 t. Portuguese waters accounted for 27.6% of abundance (244 million fish) and 72.6% of the total estimated biomass (17038 t), values from which could be inferred a large body size on average. In contrast, the estimates from the Spanish area (640 million fish – 72.4% of abundance –; 6422 t – 27.4% of biomass –), denote a dominance of the smallest sardines.

Mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The distribution of the back-scattering energy attributed to this species is shown in **Figure 14**.

Mackerel was mainly distributed over the central part of the Gulf, with a null occurrence in both extremes of the surveyed area (**Figure 14**).

Chub mackerel

Parameters of the survey's length-weight relationship are shown in **Table 4**. The distribution of the back-scattering energy attributed to this species is shown in **Figure 15**.

Although practically occurring all over the surveyed area, chub mackerel showed the highest densities westward the Guadiana river mouth (**Figure 15**).

Blue jack-mackerel

The survey's length-weight relationship for this species is given in **Table 4**. The distribution of the back-scattering energy attributed to this species is illustrated in **Figure 16**.

The distribution pattern of blue jack mackerel almost mimics the previously described one for chub mackerel, suggesting the occupation of similar habitats by both species, although blue jack mackerel was absent in the most part of the Spanish waters (**Figure 16**, see also **Figure 15** for comparison).

Horse mackerel

The survey's length-weight relationship for horse mackerel is shown in **Table 4**. The back-scattering energy attributed to this species is shown in **Figure 17**.

Horse mackerel also showed widely distributed over the surveyed area, sharing the same distribution pattern than the above described for chub mackerel and blue jack mackerel. Again, the westernmost Portuguese shelf waters were those ones where the species recorded the highest densities (**Figure 17**).

Mediterranean horse-mackerel

The survey's length-weight relationship for this species is shown in **Table 4**. Back-scattering energy attributed to the species is represented in **Figure 18**.

Mediterranean horse-mackerel was only present over the Spanish inner shelf waters, with the densest concentrations being recorded in the coastal fringe between Cadiz Bay and Cape Trafalgar (**Figure 18**).

Bogue

Parameters of the survey's length-weight relationship for bogue are shown in **Table 4**. Back-scattering energy attributed to bogue is shown in **Figure 19**.

Although showing a relatively widespread distribution, bogue showed their higher acoustic densities in the westernmost Portuguese inner shelf waters (**Figure 19**).

Boarfish and Blue whiting

Boarfish showed an incidental occurrence in the surveyed area, just in the outer shelf waters to the east of Cape Santa Maria. Blue whiting showed a very restricted distribution which was confined to the outer shelf of the westernmost Portuguese waters.

Oceanographic conditions

A detailed description of the oceanographic conditions in that survey based on *in situ* and remotely sensed data is given in Sánchez-Leal *et al*. (2015).

(SHORT) DISCUSSION

The historical series of anchovy biomass estimates is shown in **Figure 22**. The summer 2015 abundance estimate continues the notable increasing trend which started last year and rises up the population levels well above those corresponding to the historical average. This increasing trend in abundance is not completely coupled to the trend exhibited by the biomass, which showed a relatively low decrease in relation to the previous year estimate. Even so, the 2015 biomass estimate situates only slightly below the historical average.

For this same surveyed area, the Portuguese spring survey PELAGO 15 estimated two months before 3689 million fish and 33100 t (158 million and 2156 t in Portuguese waters, 3531 million and 30944 t in Spanish ones; see Marques *et al*., 2015, WD). The comparison of these estimates with their summer counterparts evidences almost identical values for the Portuguese waters, whereas the ECOCADIZ survey estimated in summer at about 1000 million and 11800 t less of anchovy in the Spanish waters. Even assuming a total mortality (Z) accumulated between surveys, the magnitude of such differences should be explainable by causes other than the above one. Marques *et al*. (2015, WD) warn about the need of corroborating the PELAGO spring estimates with the ECOCADIZ ones because of some uncertainty in the estimation. These authors advanced the possibility of a certain overestimation of the acoustic energy attributed to anchovy in the Spanish waters of the Gulf because this energy in this area was strongly masked by a dense plankton layer. ECOCADIZ surveys also routinely face to this same problem, since this situation is not uncommon in the area, by acoustically surveying in a multi-frequency fashion, an approach that partially enables a more efficient discrimination of echoes.

Regarding sardine, although its population levels have showed some recovery from the lowest values recorded in the two previous years, the 2015 estimates are still below the historical average (**Figure 22**). The comparison of the ECOCADIZ 2015-07 estimates with their spring counterparts reveals some differences (see Marques et *al*., 2015, WD). PELAGO survey estimated 400 million and 16663 t of Gulf of Cadiz sardine (238 million and 15031 t in Portuguese waters, 162 million and 1632 t in Spanish ones). As it could be easily deduced from the above values, spring and summer estimates from the Portuguese Algarve area were quite similar. However, ECOCADIZ survey estimated in summer 4 fold more sardine in the Spanish waters than PELAGO survey in spring, with the juvenile fraction being the dominant in both seasons. The progressive incorporation (recruitment) of juveniles coming from successive spawning events may be the reason for such differences.

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Table 1. *ECOCADIZ 2015-07 s*urvey. Descriptive characteristics of the acoustic tracks.

Acoustic Track	Location	Date	Start				End			
			Latitude	Longitude	UTC time	Mean depth (m)	Latitude	Longitude	UTC time	Mean depth (m)
R01	Trafalgar	29/07/15	36º 13.597' N	5º 07.650 ' W	06:04	25	36º 02.168' N	6º 28.736' W	08:15	180
R02	Sancti-Petri	29/07/15	36º 08.782' N	6º 33.470' W	09:07	216	36º 19.203' N	6º 14.817' W	11:01	27
R03	Cádiz	30/07/15	36º 27.127' N	6º 19.269' W	06:11	32	36º 16.250' N	6º 37.899' W	10:18	246
R04	Rota	30/07/15	36º 23,429' N	6º 42.054' W	11:20	256	36º 34.556' N	6º 23.076' W	18:10	21
R05	Chipiona	31/07/15	36º 40.078' N	6º 29.990' W	06:04	23	36º 30.970' N	6º 46.291' W	07:41	197
R06	Doñana	31/07/15	36º 37.019' N	6º 53.573' W	10:21	203	36º 46.447' N	6º 35.889' W	13:35	23
R07	Matalascañas	01/08/15	36º 43.959' N	6º 58.038' W	06:21	177	36º 53.689' N	6º 40.752' W	09:56	20
R08	Mazagón	01/08/15	37º 15.670' N	6º 44.432' W	10:53	21	36º 49.652' N	7º 06.395' W	14:34	104
R09	Punta Umbría	02/08/15	36º 49.694' N	7º 06.360' W	07:22	165	37º 03.332' N	6º 56.760' W	11:07	20
R10	El Rompido	02/08/15	37º 06.881' N	7º 06.895º W	12:08	23	36º 49.822' N	7º 06.803' W	14:46	219
R11	Isla Cristina	03/08/15	37º 06.955' N	7º 16.991' W	05:59	23	36º 53.200' N	07º 16.714' W	09:29	144
R12	V.R. do Sto. Antonio	03/08/15	36º 56.377' N	7º 26.502' W	14:35	160	37º 06.321' N	7º 26.516' W	15:34	22
R13	Tavira	04/08/15	36º 57.223' N	7º 36.072' N	06:07	123	37º 04.910' N	7º 36.085' W	06:48	20
R14	Fuzeta	04/08/15	36º 55.905' N	7º 45.988' W	13:53	160	36º 59.233' N	7º 45.876' W	14:19	80
R15	Cabo Sta. María	05/08/15	36º 55.104' N	7º 56.026' W	06:08	75	36º 52.102' N	7º 55.999' W	06:26	158
R16	Cuarteira	05/08/15	36º 50.191' N	8º 05.871' W	07:32	114	37º 01.264' N	8º 05.895' W	10:18	20
R17	Albufeira	06/08/15	36º 49.383' N	08º 15.490' W	06:05	196	37º 02.430' N	8º 15.428' W	09:10	26
R18	Alfanzina	06/08/15	37º 03.963' N	8º 25.288' N	10:50	35	36º 50.324' N	8º 25.303' W	12:21	217
R19	Portimao	07/08/15	37º 05.382' N	8º 35.410' W	06:02	34	36º 51.380' N	8º 35.400' W	07:26	209
R20	Burgau	07/08/15	36º 52.436' N	8º 44.940' W	10:19	109	37º 03.855' N	8º 45.005' W	11:41	29
R21	Punta de Sagres	07/08/15	37º 00.430' N	8º 55.024' W	12:43	24	36º 50.616' N	8º 55.007' W	13:42	192

Table 2. *ECOCADIZ 2015-07* survey. Descriptive characteristics of the fishing stations. Null hauls in light grey.

Fishing station	Date	Start		End		UTC Time		Depth (m)		Duration (min.)		Trawled Distance (nm)	Acoustic transect	Zone (landmark)
		Latitude	Longitude	Latitude	Longitude	Start	End	Start	End	Effective trawling	Total manoeuvre			
01	28-07-2015	36º 28.2810 N	6º 28.9879 W	36º 27.3140 N	6º 28.4989 W	16:32	16:45	56,84	55,30	00:13	n.a	1,04	n.a.	TEST HAULS
02	28-07-2015	36º 23.2678 N	6º 27.4259 W	36º 23.4269 N	6º 27.3890 W	17:42	17:45	60,45	60,34	00:03	00:33	0,16	n.a	
03	29-07-2015	36º 16.0768 N	6º 20.4979 W	36º 13.9151 N	6º 23.9889 W	11:59	12:52	52,12	47,45	00:53	01:16	3,55	R02i	Sancti-Petri
04	30-07-2015	36º 25.3319 N	6º 24.1559 W	36º 22.4079 N	6º 22.3459 W	07:43	08:33	47,02	47,00	00:50	01:14	3,27	R03	Cádiz
05	30-07-2015	36º 30.6919 N	6º 29.9479 W	36º 29.0750 N	6º 32.6220 W	13:47	14:27	71,42	55,33	00:40	01:03	2,69	R04	Rota
06	30-07-2015	36º 30.4319 N	6º 27.3649 W	36º 32.7900 N	6º 29.6270 W	16:28	17:08	47,42	46,53	00:40	01:06	2,98	R04	Rota
07	31-07-2015	36º 32.1890 N	6º 43.8599 W	36º 33.9099 N	6º 40.9610 W	08:11	08:51	91,05	116,11	00:40	01:13	2,90	R05	Chipiona
08	31-07-2015	36º 42.2129 N	6º 43.7989 W	36º 40.5919 N	6º 46.7429 W	12:08	12:50	97,10	67,92	00:42	01:12	2,87	R06	Doñana
09	31-07-2015	36º 40.1559 N	6º 36.1929 W	36º 41.9270 N	6º 38.2270 W	15:57	16:33	37,67	38,30	00:36	00:59	2,41	No data	No data
10	01-08-2015	36º 45.7310 N	6º 54.8749 W	36º 44.5930 N	6º 57.0380 W	07:23	07:53	131,12	110,11	00:30	01:14	2,08	R07	Matalascañas
11	01-08-2015	36º 53.4738 N	6º 59.1979 W	36º 55.1390 N	6º 56.6409 W	13:06	13:44	69,20	93,43	00:38	01:16	2,64	R08	Mazagón
12	02-08-2015	36º 53.1990 N	7º 03.5749 W	36º 50.6160 N	7º 04.8579 W	08:26	09:07	130,89	104,76	00:41	01:14	2,78	No data	No data
13	03-08-2015	37º 00.5039 N	7º 15.4910 W	37º 00.5039 N	7º 12.9119 W	07:44	08:13	72,48	73,57	00:29	01:00	2,07	No data	No data
14	03-08-2015	36º 55.5198 N	7º 13.7529 W	36º 56.3809 N	7º 16.9010 W	11:38	12:17	110,84	111,74	00:39	01:18	2,67	R11	Isla Cristina
15	04-08-2015	37º 02.1679 N	7º 37.8149 W	37º 02.9720 N	7º 35.6199 W	07:44	08:15	50,65	61,04	00:31	00:56	1,93	R13	Tavira
16	04-08-2015	37º 00.1430 N	7º 35.9080 W	36º 57.3060 N	7º 35.9339 W	11:38	12:20	172,28	96,77	00:42	01:16	2,83	R13	Tavira
17	04-08-2015	36º 55.4850 N	7º 45.5340 W	36º 57.4188 N	7º 46.4499 W	14:59	15:27	87,60	107,63	00:28	00:49	2,07	R14	Fuzeta
18	05-08-2015	36º 53.4990 N	8º 05.7380 W	36º 51.6169 N	8º 05.7679 W	08:15	08:42	110,27	95,71	00:27	01:00	1,88	R16	Cuarteira
19	05-08-2015	36º 56.9801 N	8º 02.9600 W	36º 56.9579 N	8º 04.8430 W	11:33	11:55	43,93	43,65	00:22	00:56	1,51	R16	Cuarteira
20	06-08-2015	36º 54.3800 N	8º 15.6069 W	36º 52.0390 N	8º 15.5600 W	07:02	07:35	114,12	96,95	00:33	01:03	2,34	R17	Albufeira
21	06-08-2015	36º 56.9989 N	8º 19.3429 W	36º 57.0169 N	8º 22.3990 W	14:33	15:09	80,31	77,36	00:36	00:54	2,45	R17	Albufeira
22	07-08-2015	36º 52.0619 N	8º 35.4089 W	36º 53.7950 N	8º 35.3470 W	08:11	08:37	111,72	116,30	00:26	01:14	1,73	R19	Portimao

Table 3. *ECOCADIZ 2015-07* survey. Catches by species in number (upper panel) and weight (in kg, lower panel) from valid fishing stations.

ABUNDANCE (nº)												
Fishing station	***Anchovy***	***Sardine***	***Chub mack.***	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Blue whiting***	***Boarfish***	**Other spp.**	**TOTAL**
03	0	0	10	0	0	0	1695	0	0	0	212	**1917**
04	155	22	0	0	0	0	133	1	0	0	316	**627**
05	8197	3856	0	2	4	0	0	4	0	0	37	**12100**
06	6701	1106	1	0	6	0	65	8	0	0	154	**8041**
07	9156	335	2	4	4	0	0	0	0	0	128	**9629**
08	21701	2961	2	3	8	0	0	1	0	0	153	**24829**
09	8440	6585	3	0	3	0	17	4	0	0	110	**15162**
10	28617	600	0	4	905	2	0	0	0	0	118	**30246**
11	7674	506	4	71	3	0	0	1	0	0	117	**8376**
12	25052	760	3	13	44	58	0	0	0	0	180	**26110**
13	30597	2069	0	1	0	0	0	0	0	0	141	**32808**
14	7837	551	9	9	212	65	0	0	0	0	249	**8932**
15	0	10930	6064	25	10	27	0	37	0	0	176	**17269**
16	7	189	6116	3	789	1913	0	0	0	105	30	**9152**
18	87	10	221	21	6086	881	0	0	4569	0	711	**12586**
19	0	21	164	0	62	16	0	2	0	0	167	**432**
20	104	8	22	18	16498	271	0	4	24	0	397	**17346**
21	1465	6250	4645	5	1376	46	0	81	0	0	357	**14225**
22	0	8296	556	4	384	47486	0	45	101	7	60	**56939**
TOTAL	**155790**	**45055**	**17822**	**183**	**26394**	**50765**	**1910**	**188**	**4694**	**112**	**3813**	**306726**

BIOMASS (kg)												
Fishing station	***Anchovy***	***Sardine***	***Chub mack.***	***Mackerel***	***Horse-mack.***	***Blue Jack-mack.***	***Medit. Horse-mack.***	***Bogue***	***Blue whiting***	***Boarfish***	**Other spp.**	**TOTAL**
03	0	0	3,194	0	0	0	281,800	0	0	0	45,402	**330,396**
04	1,186	0,548	0	0	0	0	26,150	0,226	0	0	42,210	**70,320**
05	44,500	44,100	0	0,538	0,270	0	0	0,614	0	0	2,722	**92,744**
06	32,950	13,212	0,242	0	0,162	0	13,850	1,662	0	0	13,614	**75,692**
07	84,200	4,306	0,210	0,528	0,122	0	0	0	0	0	7,571	**96,937**
08	133,700	35,810	0,402	0,632	0,178	0	0	0,148	0	0	7,189	**178,059**
09	28,750	62,926	0,700	0	0,142	0	3,572	0,658	0	0	34,792	**131,540**
10	280,850	7,650	0	0,806	8,500	0,068	0	0	0	0	19,482	**317,356**
11	59,450	5,752	0,512	13,450	0,056	0	0	0,202	0	0	7,544	**86,966**
12	321,900	10,488	0,180	2,192	0,386	1,124	0	0	0	0	40,941	**377,211**
13	259,800	25,550	0	0,226	0	0	0	0	0	0	6,738	**292,314**
14	119,650	10,050	0,412	1,546	2,648	1,398	0	0	0	0	21,150	**156,854**
15	0	761,420	768,076	5,949	0,741	1,585	0	5,173	0	0	34,064	**1577,008**
16	0,204	11,550	468,300	0,532	11,650	93,800	0	0	0	0,614	3,514	**590,164**
18	1,602	0,422	25,485	3,984	582,350	59,950	0	0	88,650	0	34,062	**796,505**
19	0	1,390	20,200	0	4,250	1,008	0	0,208	0	0	28,776	**55,832**
20	2,640	0,458	1,884	4,768	680,650	11,700	0	0,416	0,508	0	26,548	**729,572**
21	29,990	466,830	582,570	1,284	103,412	2,806	0	8,650	0	0	20,468	**1216,010**
22	0	493,989	41,966	1,600	4,107	2783,388	0	4,618	1,768	0,034	4,857	**3336,327**
TOTAL	**1401,372**	**1956,451**	**1914,333**	**38,035**	**1399,624**	**2956,827**	**325,372**	**22,575**	**90,926**	**0,648**	**401,644**	**10507,807**

Table 4. *ECOCADIZ 2015-07* survey. Parameters of the size-weight relationships for survey's target species. FAO codes for the species: PIL: *Sardina pilchardus*; ANE: *Engraulis encrasicolus*; MAS: *Scomber colias*; MAC: *Scomber scombrus*; JAA: *Trachurus picturatus;* HOM: *Trachurus trachurus*; HMM: *Trachurus mediterraneus*; BOG: *Boops boops*; WHB: *Micromesistius poutassou*; BOC: *Capros aper*.

Parameter	PIL	ANE	MAS	MAC	JAA	HOM	HMM	BOG	WHB	BOC
n	832	935	346	147	375	779	167	102	67	104
a	0,0032841	0,0025842	0,0037685	0,0011541	0,0045714	0,0063080	0,0288680	0,0144710	1,1600958	0,0275365
b	3,3258776	3,3588280	3,2463239	3,5490388	3,2085855	3,0986631	2,6106969	2,8711550	1,0360549	2,8409697
r^2	0,9881491	0,9799551	0,9683588	0,9671916	0,9820176	0,9946606	0,8350312	0,9553940	0,2086417	0,8461715

Table 5. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 9**.

ECOCADIZ 2015-07. *Engraulis encrasicolus*. ABUNDANCE (in number and million fish)																
Size class	POL01	POL02	POL03	POL04	POL05	POL06	POL07	POL08	POL09	POL10	*n*			millions		
											PORTUGAL	SPAIN	TOTAL	PORTUGAL	SPAIN	TOTAL
6	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	83224	0	563323	0	0	0	0	0	83224	563323	646547	**0,1**	**1**	**1**
7	0	0	332895	0	2253295	0	9668684	0	0	0	332895	11921979	12254874	**0,3**	**12**	**12**
7,5	0	0	1748750	0	11836929	0	125546382	0	0	0	1748750	137383311	139132061	**2**	**137**	**139**
8	0	0	2415592	0	16350649	0	251166011	8955528	0	0	2415592	276472188	278887780	**2**	**276**	**279**
8,5	0	0	1415855	0	9583635	0	170666904	82567194	0	0	1415855	262817733	264233588	**1**	**263**	**264**
9	0	0	499342	0	3379941	0	38674731	143227947	0	0	499342	185282619	185781961	**0,5**	**185**	**186**
9,5	0	0	720954	0	4879991	0	12891577	137394611	2352741	599718	720954	158118638	158839592	**1**	**158**	**159**
10	0	0	5074524	310517	34348415	1943326	6445792	106566167	16879684	1759172	5385041	167942556	173327597	**5**	**168**	**173**
10,5	0	0	20161712	776870	136470504	4861929	3222893	68179072	79551178	1839134	20938582	294124710	315063292	**21**	**294**	**315**
11	0	0	16925684	2098723	114566489	13134560	0	45095297	119168678	1199435	19024407	293164459	312188866	**19**	**293**	**312**
11,5	0	0	8601135	5483546	58219323	34318002	0	16411715	118218004	479774	14084681	227646818	241731499	**14**	**228**	**242**
12	1059733	18848	2785264	10779193	18852880	67460064	0	12022733	64637723	119944	14643038	163093344	177736382	**15**	**163**	**178**
12,5	4178377	83124	2035197	11790257	13775835	73787667	0	2968197	26995896	79962	18086955	117607557	135694512	**18**	**118**	**136**
13	11869012	224008	833290	11708481	5640368	73275886	0	0	20568164	79962	24634791	99564380	124199171	**25**	**100**	**124**
13,5	16077667	322849	499342	7459560	3379941	46684608	0	1978797	5738474	79962	24359418	57861782	82221200	**24**	**58**	**82**
14	7327298	141969	249671	4298906	1689972	26904101	0	0	1024998	0	12017844	29619071	41636915	**12**	**30**	**42**
14,5	3148922	77693	0	1984884	0	12422116	0	0	2663482	0	5211499	15085598	20297097	**5**	**15**	**20**
15	363337	34438	0	914965	0	5726179	0	0	0	0	1312740	5726179	7038919	**1**	**6**	**7**
15,5	363337	82166	0	228741	0	1431545	0	0	0	0	674244	1431545	2105789	**1**	**1**	**2**
16	0	85552	83224	0	563323	0	0	0	0	0	168776	563323	732099	**0,2**	**1**	**1**
16,5	0	63318	0	0	0	0	0	0	0	0	63318	0	63318	**0,1**	**0**	**0,1**
17	0	22235	0	0	0	0	0	0	0	0	22235	0	22235	**0,02**	**0**	**0,02**
17,5	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	44387683	1156200	64465655	57834643	436354813	361949983	618282974	625367258	457799022	6237063	167844181	2505991113	2673835294	**168**	**2506**	**2674**
Millions	**44**	**1**	**64**	**58**	**436**	**362**	**618**	**625**	**458**	**6**						

Table 5. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Cont'd.

ECOCADIZ 2015-07. *Engraulis encrasicolus*. BIOMASS (t)													
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**POL10**	**PORTUGAL**	**SPAIN**	**TOTAL**
6	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
6,5	0	0	0,131	0	0,888	0	0	0	0	0	**0,131**	**0,888**	**1,019**
7	0	0	0,667	0	4,517	0	19,383	0	0	0	**0,667**	**23,90**	**24,567**
7,5	0	0	4,386	0	29,688	0	314,878	0	0	0	**4,386**	**344,566**	**348,952**
8	0	0	7,474	0	50,591	0	777,139	27,710	0	0	**7,474**	**855,440**	**862,914**
8,5	0	0	5,338	0	36,133	0	643,456	311,299	0	0	**5,338**	**990,888**	**996,226**
9	0	0	2,269	0	15,358	0	175,735	650,816	0	0	**2,269**	**841,909**	**844,178**
9,5	0	0	3,910	0	26,463	0	69,908	745,062	12,758	3,252	**3,910**	**857,443**	**861,353**
10	0	0	32,551	1,992	220,334	12,466	41,348	683,587	108,278	11,285	**34,543**	**1077,298**	**1111,841**
10,5	0	0	151,767	5,848	1027,280	36,598	24,260	513,217	598,821	13,844	**157,615**	**2214,02**	**2371,635**
11	0	0	148,427	18,404	1004,673	115,181	0	395,456	1045,031	10,518	**166,831**	**2570,859**	**2737,690**
11,5	0	0	87,288	55,649	590,836	348,275	0	166,553	1199,729	4,869	**142,937**	**2310,262**	**2453,199**
12	12,370	0,220	32,513	125,827	220,073	787,472	0	140,343	754,527	1,400	**170,93**	**1903,815**	**2074,745**
12,5	55,790	1,110	27,174	157,423	183,934	985,210	0	39,631	360,448	1,068	**241,497**	**1570,291**	**1811,788**
13	180,331	3,403	12,661	177,892	85,697	1113,314	0	0	312,502	1,215	**374,287**	**1512,728**	**1887,015**
13,5	276,638	5,555	8,592	128,352	58,157	803,273	0	34,048	98,738	1,376	**419,137**	**995,592**	**1414,729**
14	142,146	2,754	4,844	83,397	32,785	521,928	0	0	19,885	0	**233,141**	**574,598**	**807,739**
14,5	68,590	1,692	0	43,235	0	270,579	0	0	58,016	0	**113,517**	**328,595**	**442,112**
15	8,852	0,839	0	22,291	0	139,506	0	0	0	0	**31,982**	**139,506**	**171,488**
15,5	9,865	2,231	0	6,211	0	38,868	0	0	0	0	**18,307**	**38,868**	**57,175**
16	0	2,580	2,510	0	16,988	0	0	0	0	0	**5,090**	**16,988**	**22,078**
16,5	0	2,114	0	0	0	0	0	0	0	0	**2,114**	**0**	**2,114**
17	0	0,819	0	0	0	0	0	0	0	0	**0,819**	**0**	**0,819**
17,5	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
18	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	**754,582**	**23,317**	**532,502**	**826,521**	**3604,395**	**5172,67**	**2066,107**	**3707,722**	**4568,733**	**48,827**	**2136,922**	**19168,454**	**21305,376**

Table 6. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Estimated abundance (absolute numbers and million fish) and biomass (t) by size class (in cm). Polygons (*i.e.*, coherent or homogeneous post-strata) numbered as in **Figure 12**.

***ECOCADIZ 2015-07*. *Sardina pilchardus*. ABUNDANCE (in number and million fish)**															
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	***n***			**millions**		
										PORTUGAL	**SPAIN**	**TOTAL**	**PORTUGAL**	**SPAIN**	**TOTAL**
7	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	7305	0	197399	0	0	0	7305	197399	204704	**0,01**	**0,2**	**0,2**
8	0	0	0	32227	0	870879	0	0	0	32227	870879	903106	**0,03**	**1**	**1**
8,5	0	0	0	39531	0	1068278	0	0	0	39531	1068278	1107809	**0,04**	**1**	**1**
9	0	0	0	24922	0	673480	0	0	0	24922	673480	698402	**0,02**	**1**	**1**
9,5	0	0	0	18047	0	487692	0	0	0	18047	487692	505739	**0,02**	**0,5**	**1**
10	0	0	0	22507	0	608204	0	122006765	0	22507	122614969	122637476	**0,02**	**123**	**123**
10,5	0	0	0	292628	0	7907822	0	212672346	117919	292628	220698087	220990715	**0,3**	**221**	**221**
11	0	0	0	1174259	0	31732573	0	103202054	3601884	1174259	138536511	139710770	**1**	**139**	**140**
11,5	0	0	0	1610526	21828	43522023	23989	43803039	9479733	1632354	96828784	98461138	**2**	**97**	**98**
12	0	0	0	766362	574791	20709766	631704	3134117	6374908	1341153	30850495	32191648	**1**	**31**	**32**
12,5	0	0	0	325618	807617	8799340	887584	0	2530870	1133235	12217794	13351029	**1**	**12**	**13**
13	0	0	0	64687	1462442	1748056	1607246	3134117	1180673	1527129	7670092	9197221	**2**	**8**	**9**
13,5	0	0	0	29172	465653	788322	511760	0	235061	494825	1535143	2029968	**0,5**	**2**	**2**
14	0	0	1624	11329	509308	306161	559737	149242	0	522261	1015140	1537401	**1**	**1**	**2**
14,5	0	0	0	8049	145517	217523	159925	223865	0	153566	601313	754879	**0,2**	**1**	**1**
15	0	0	0	8049	21828	217523	23989	596976	0	29877	838488	868365	**0,03**	**1**	**1**
15,5	0	0	0	8049	0	217523	0	895464	0	8049	1112987	1121036	**0,01**	**1**	**1**
16	0	0	0	4025	0	108761	0	373111	0	4025	481872	485897	**0,00**	**0,5**	**0,5**
16,5	0	136956	1624	0	0	0	0	596976	0	138580	596976	735556	**0,1**	**1**	**0,7**
17	1500732	546470	0	0	0	0	0	298488	0	2047202	298488	2345690	**2**	**0,3**	**2**
17,5	0	1777020	19487	0	0	0	0	74623	0	1796507	74623	1871130	**2**	**0,1**	**2**
18	3001465	3774009	50343	0	0	0	0	149242	0	6825817	149242	6975059	**7**	**0,1**	**7**
18,5	14305683	4792190	58462	0	0	0	0	0	0	19156335	0	19156335	**19**	**0**	**19**
19	26350523	4419867	82822	0	0	0	0	0	0	30853212	0	30853212	**31**	**0**	**31**
19,5	36894631	3637778	47095	0	0	0	0	149242	0	40579504	149242	40728746	**41**	**0,1**	**41**
20	45158403	1926381	40599	0	0	0	0	0	23358	47125383	23358	47148741	**47**	**0,02**	**47**
20,5	43657671	629735	4872	0	0	0	0	0	0	44292278	0	44292278	**44**	**0**	**44**
21	26350523	268675	0	0	0	0	0	0	0	26619198	0	26619198	**27**	**0**	**27**
21,5	12044840	44988	0	0	0	0	0	0	0	12089828	0	12089828	**12**	**0**	**12**
22	760111	0	0	0	0	0	0	0	0	760111	0	760111	**1**	**0**	**1**
22,5	3001465	0	0	0	0	0	0	0	0	3001465	0	3001465	**3**	**0**	**3**
23	0	0	0	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL *n*	213026047	21954069	306928	4447292	4008984	120181325	4405934	491459667	23544406	243743320	639591332	883334652	**244**	**640**	**883**
Millions	**213**	**22**	**0**	**4**	**4**	**120**	**4**	**491**	**24**						

Table 6. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Cont'd

ECOCADIZ 2015-07. *Sardina pilchardus*. BIOMASS (t)												
Size class	**POL01**	**POL02**	**POL03**	**POL04**	**POL05**	**POL06**	**POL07**	**POL08**	**POL09**	**PORTUGAL**	**SPAIN**	**TOTAL**
7	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
7,5	0	0	0	0,022	0	0,588	0	0	0	**0,022**	**0,588**	**0,610**
8	0	0	0	0,118	0	3,194	0	0	0	**0,118**	**3,194**	**3,312**
8,5	0	0	0	0,176	0	4,765	0	0	0	**0,176**	**4,765**	**4,941**
9	0	0	0	0,134	0	3,614	0	0	0	**0,134**	**3,614**	**3,748**
9,5	0	0	0	0,115	0	3,118	0	0	0	**0,115**	**3,118**	**3,233**
10	0	0	0	0,170	0	4,592	0	921,183	0	**0,170**	**925,775**	**925,945**
10,5	0	0	0	2,589	0	69,954	0	1881,340	1,043	**2,589**	**1952,337**	**1954,926**
11	0	0	0	12,083	0	326,534	0	1061,967	37,064	**12,083**	**1425,565**	**1437,648**
11,5	0	0	0	19,151	0,260	517,538	0,285	520,879	112,727	**19,411**	**1151,429**	**1170,840**
12	0	0	0	10,468	7,851	282,879	8,629	42,810	87,076	**18,319**	**421,394**	**439,713**
12,5	0	0	0	5,081	12,601	137,297	13,849	0	39,489	**17,682**	**190,635**	**208,317**
13	0	0	0	1,147	25,933	30,997	28,501	55,576	20,936	**27,08**	**136,01**	**163,090**
13,5	0	0	0	0,585	9,340	15,812	10,265	0	4,715	**9,925**	**30,792**	**40,717**
14	0	0	0,037	0,256	11,504	6,915	12,643	3,371	0	**11,797**	**22,929**	**34,726**
14,5	0	0	0	0,204	3,686	5,510	4,051	5,671	0	**3,890**	**15,232**	**19,122**
15	0	0	0	0,228	0,618	6,156	0,679	16,896	0	**0,846**	**23,731**	**24,577**
15,5	0	0	0	0,254	0	6,854	0	28,215	0	**0,254**	**35,069**	**35,323**
16	0	0	0	0,141	0	3,802	0	13,044	0	**0,141**	**16,846**	**16,987**
16,5	0	5,296	0,063	0	0	0	0	23,083	0	**5,359**	**23,083**	**28,442**
17	63,993	23,302	0	0	0	0	0	12,728	0	**87,295**	**12,728**	**100,023**
17,5	0	83,328	0,914	0	0	0	0	3,499	0	**84,242**	**3,499**	**87,741**
18	154,368	194,101	2,589	0	0	0	0	7,676	0	**351,058**	**7,676**	**358,734**
18,5	804,958	269,649	3,29	0	0	0	0	0	0	**1077,897**	**0**	**1077,897**
19	1618,328	271,448	5,087	0	0	0	0	0	0	**1894,863**	**0**	**1894,863**
19,5	2467,622	243,305	3,150	0	0	0	0	9,982	0	**2714,077**	**9,982**	**2724,059**
20	3282,209	140,013	2,951	0	0	0	0	0	1,698	**3425,173**	**1,698**	**3426,871**
20,5	3441,276	49,638	0,384	0	0	0	0	0	0	**3491,298**	**0**	**3491,298**
21	2248,229	22,923	0	0	0	0	0	0	0	**2271,152**	**0**	**2271,152**
21,5	1110,311	4,147	0	0	0	0	0	0	0	**1114,458**	**0**	**1114,458**
22	75,570	0	0	0	0	0	0	0	0	**75,570**	**0**	**75,570**
22,5	321,296	0	0	0	0	0	0	0	0	**321,296**	**0**	**321,296**
23	0	0	0	0	0	0	0	0	0	**0**	**0**	**0**
TOTAL	15588,160	1307,150	18,465	52,922	71,793	1430,119	78,902	4607,920	304,748	**17038,49**	**6421,689**	**23460,179**

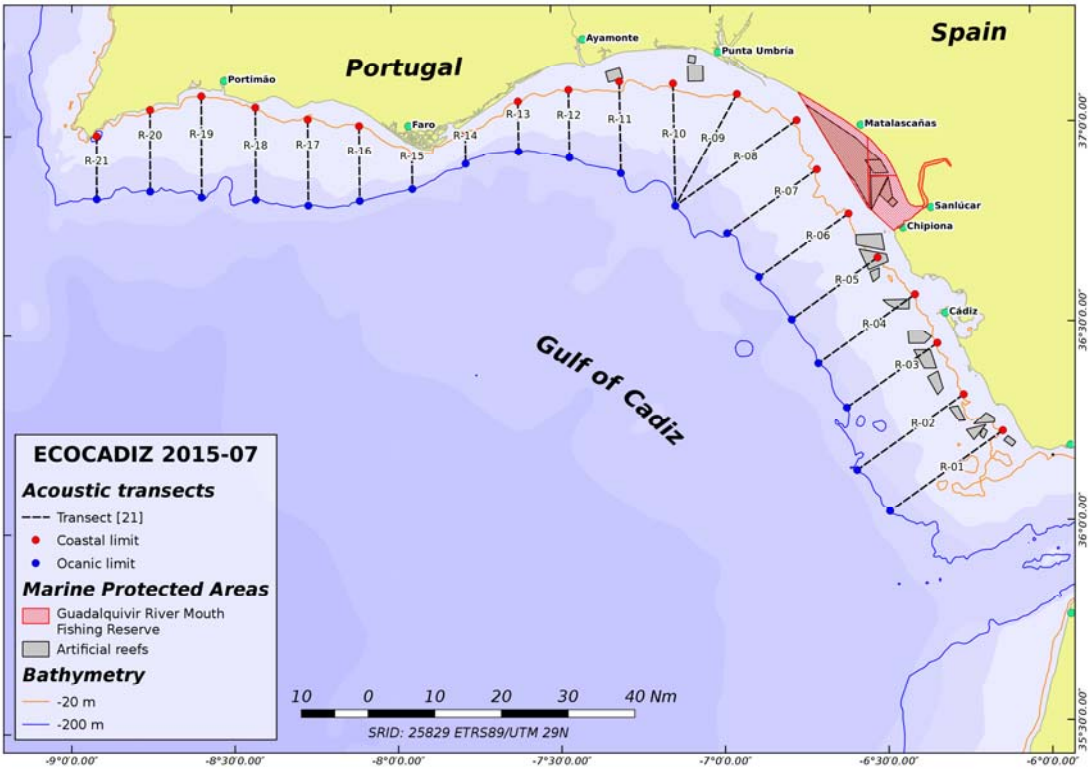


Figure 1. *ECOCADIZ 2015-07* survey. Location of the acoustic transects sampled during the survey. The different protected areas inside the Guadalquivir river mouth Fishing Reserve and artificial reef polygons are also shown.

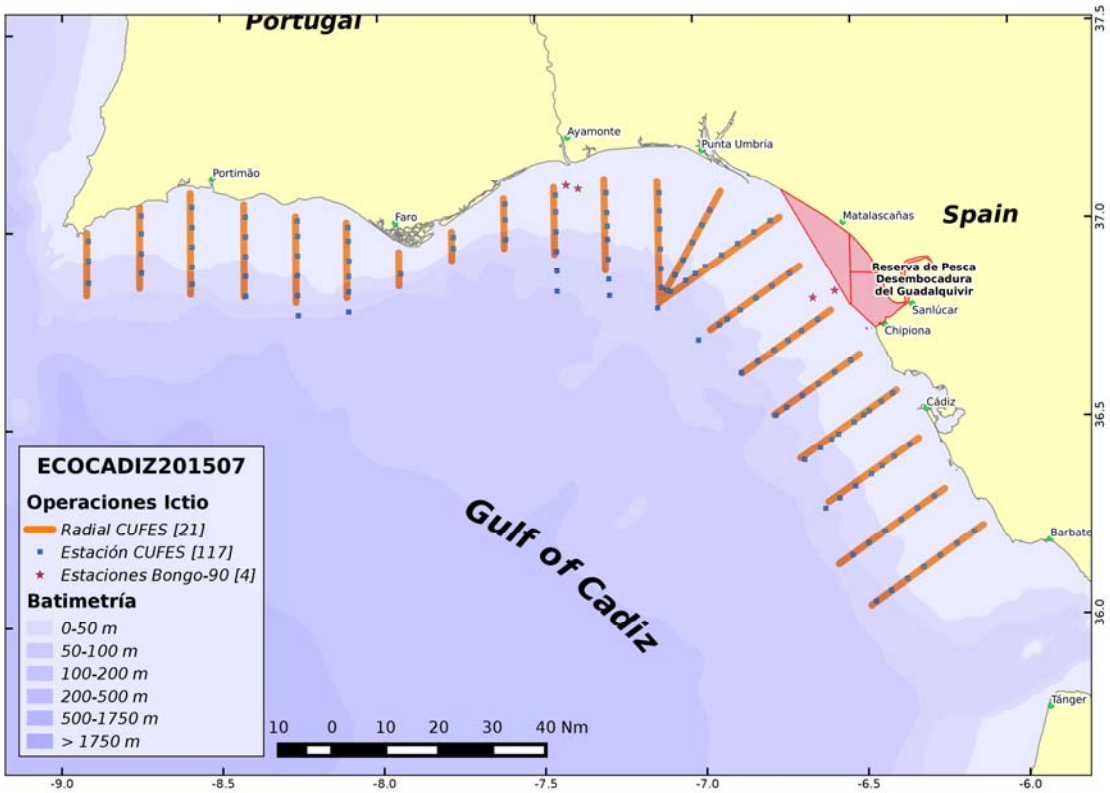


Figure 2. *ECOCADIZ 2015-07* survey. Location of CUFES and Bongo-90 sampling stations.

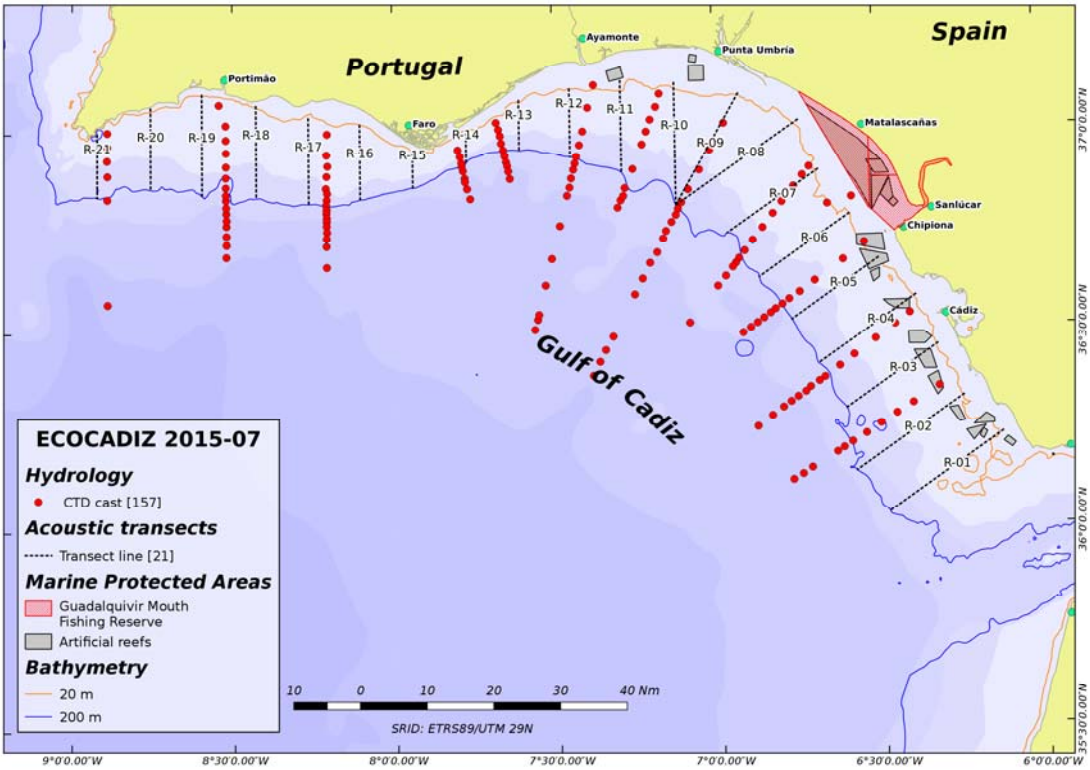


Figure 3. *ECOCADIZ 2015-07* survey. Location of CTD-LADCP stations.

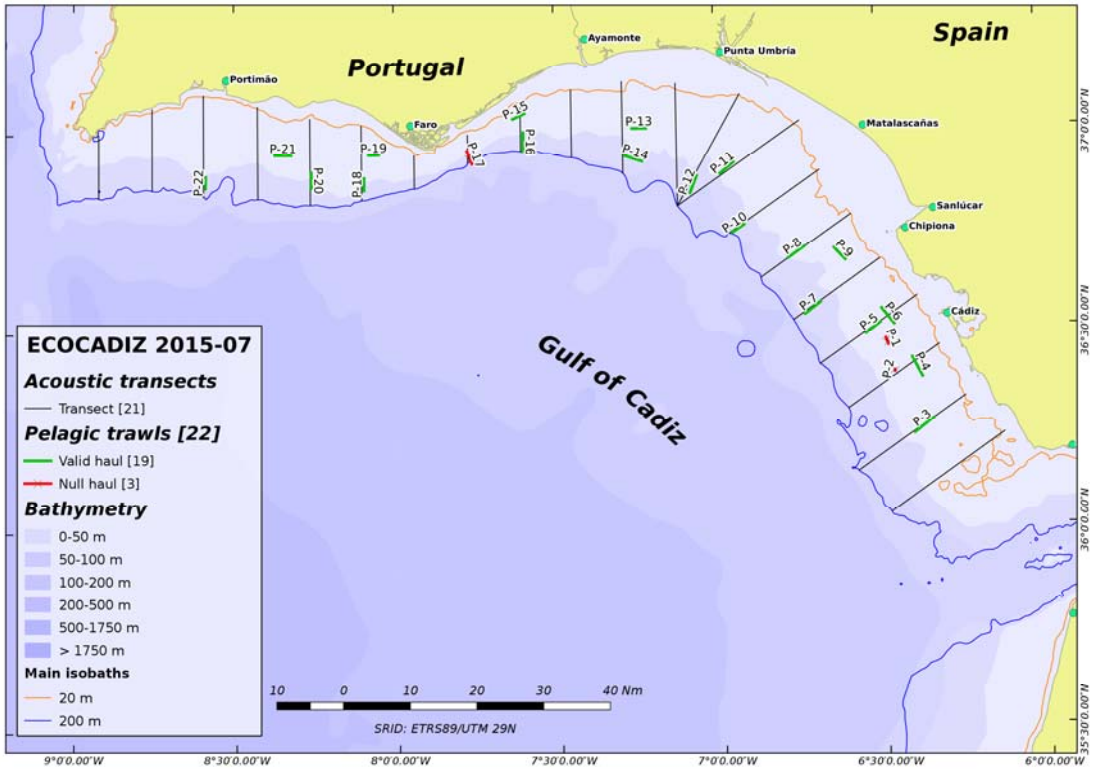


Figure 4. *ECOCADIZ 2015-07* survey. Location of ground-truthing fishing hauls. Null hauls in red.

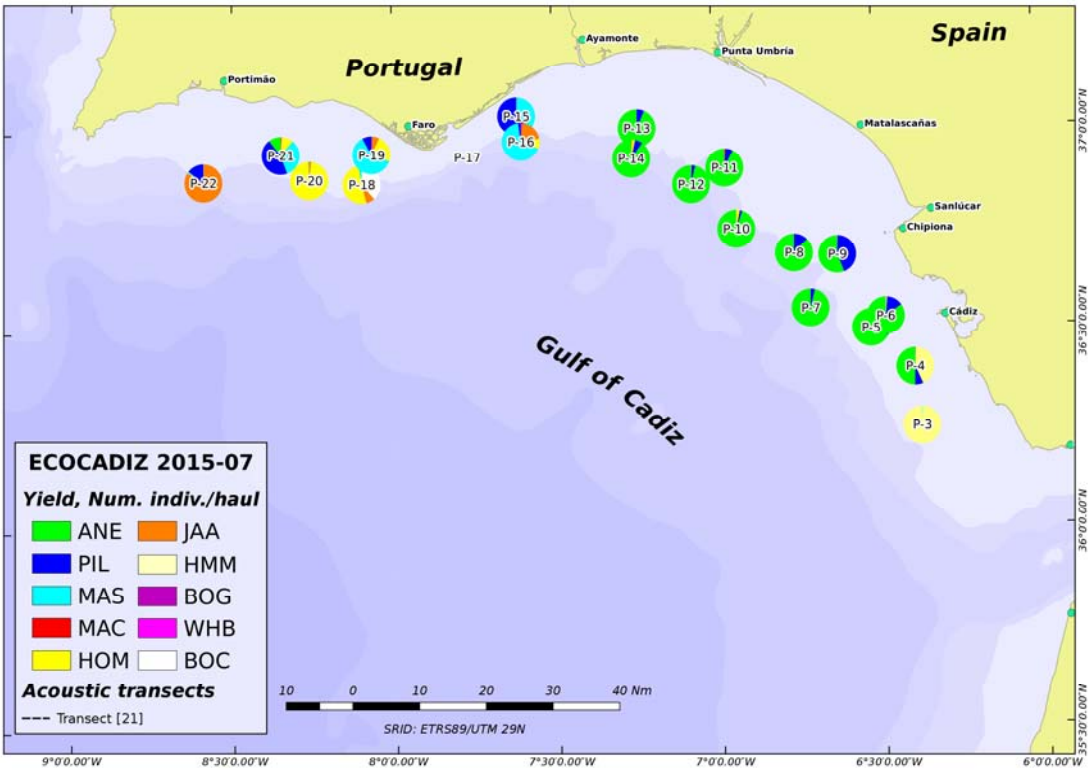


Figure 5. *ECOCADIZ 2015-07* survey. Species composition (percentages in number) in fishing hauls.

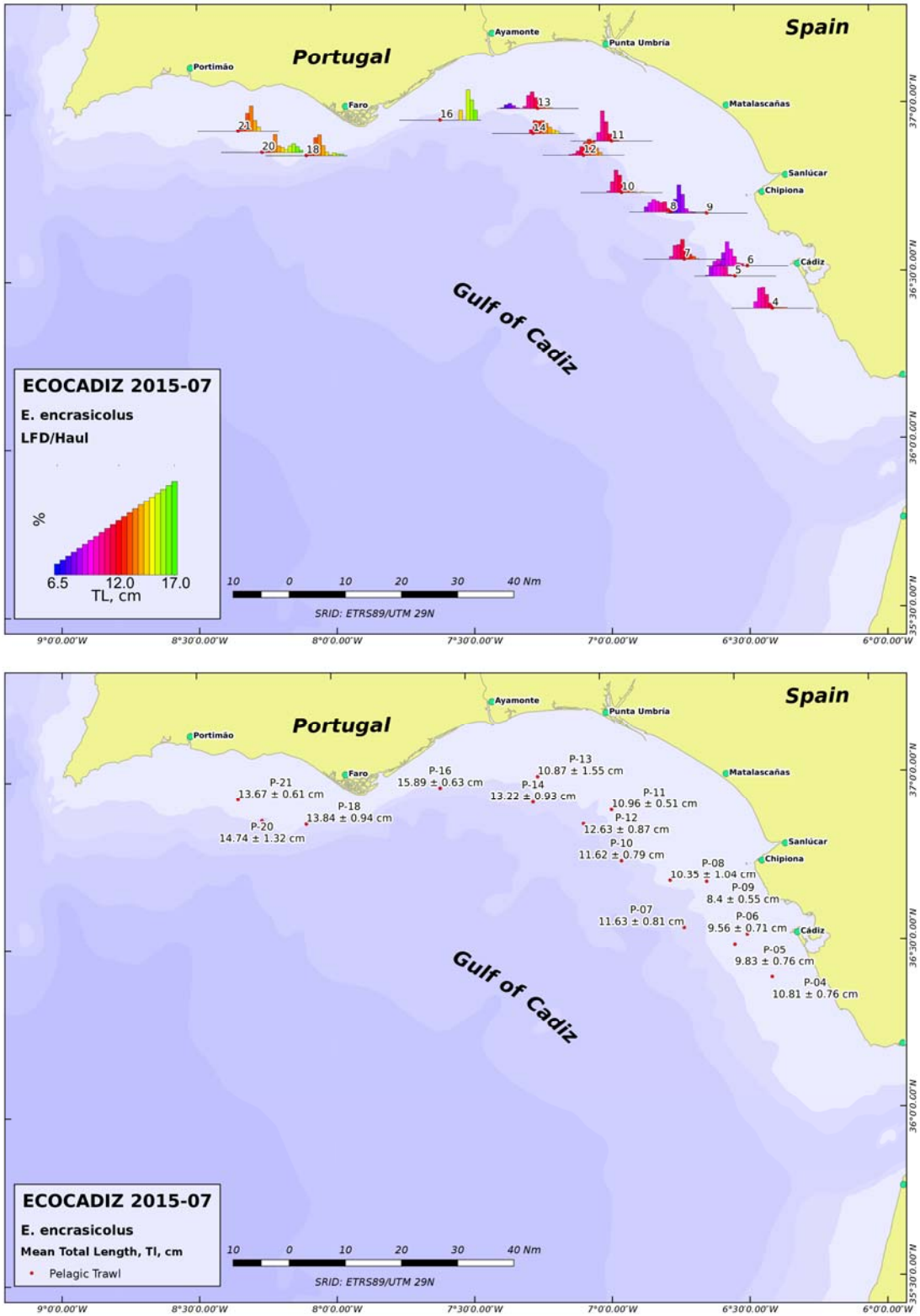


Figure 6. *ECOCADIZ 2015-07* survey. *Engraulis encrasicolus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

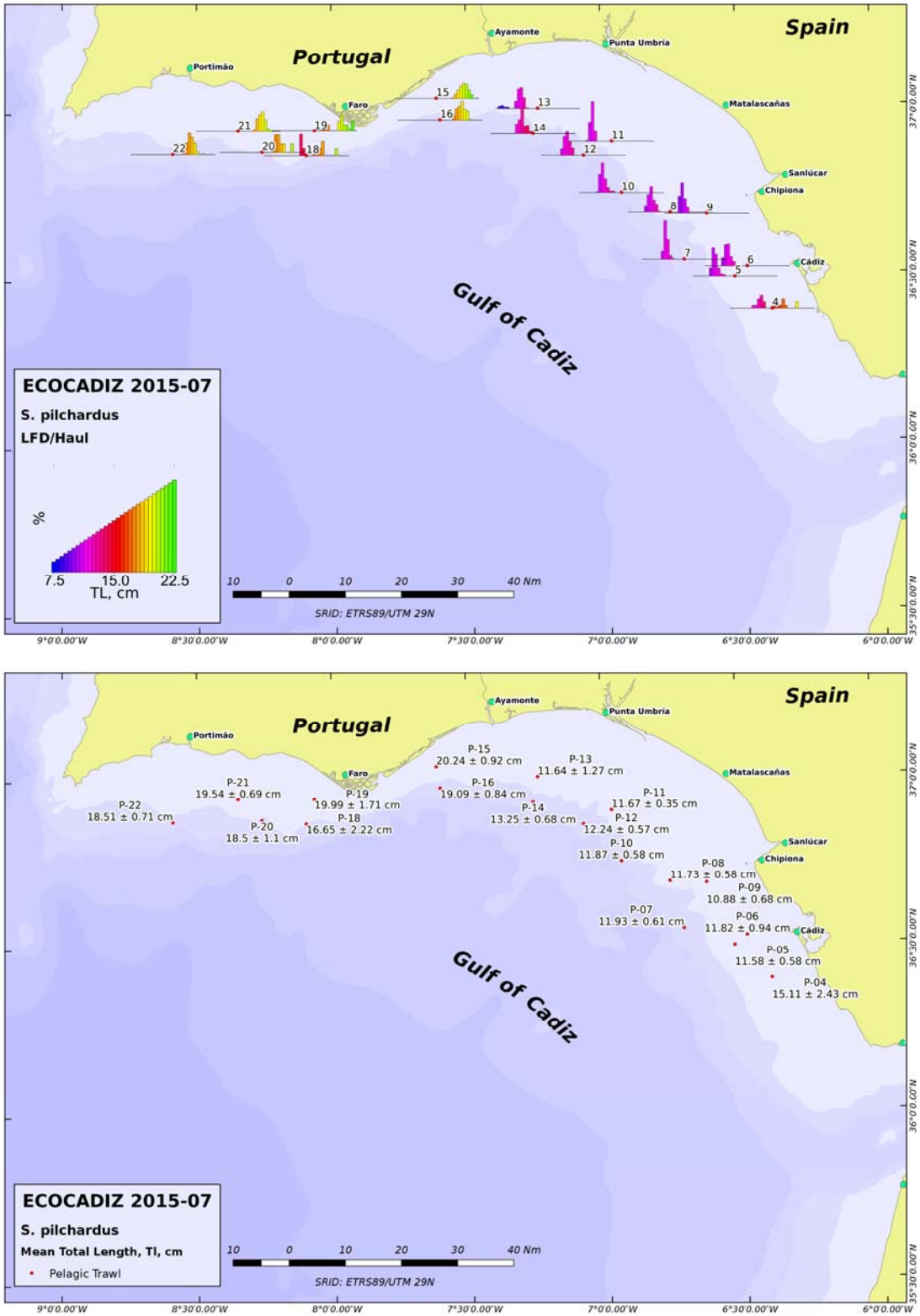


Figure 7. *ECOCADIZ 2015-07* survey. *Sardina pilchardus*. Top: length frequency distributions in fishing hauls. Bottom: mean ± sd length by haul.

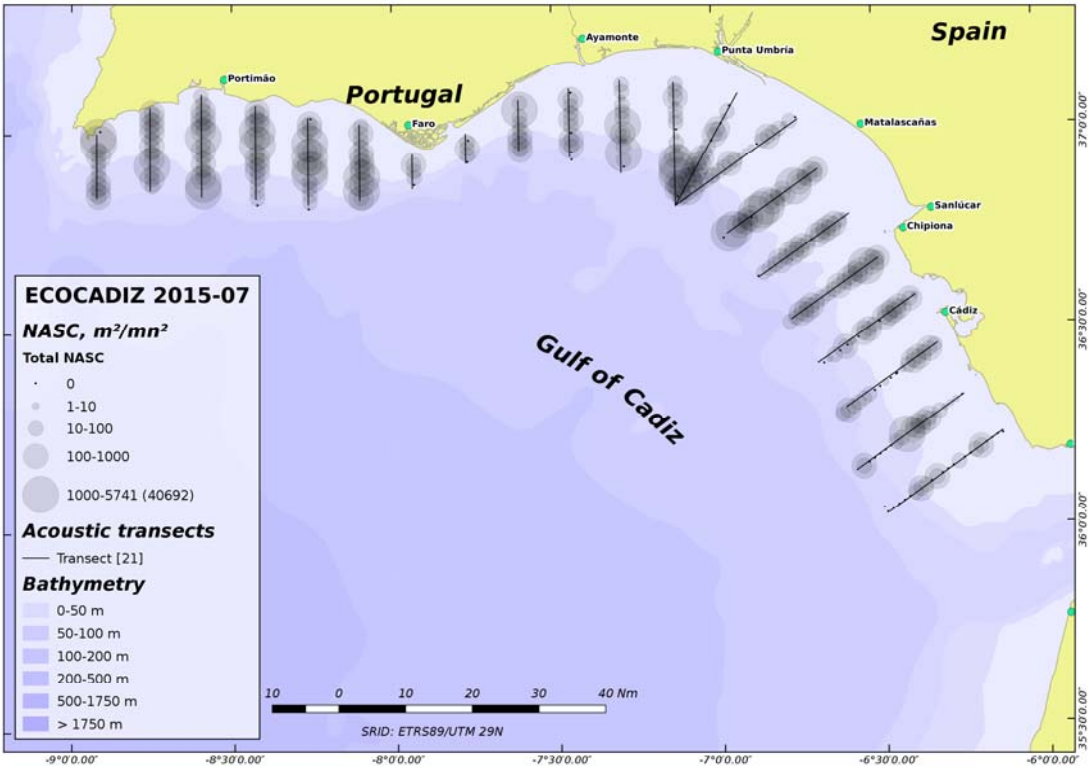


Figure 8. *ECOCADIZ 2015-07* survey. Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the pelagic fish species assemblage.

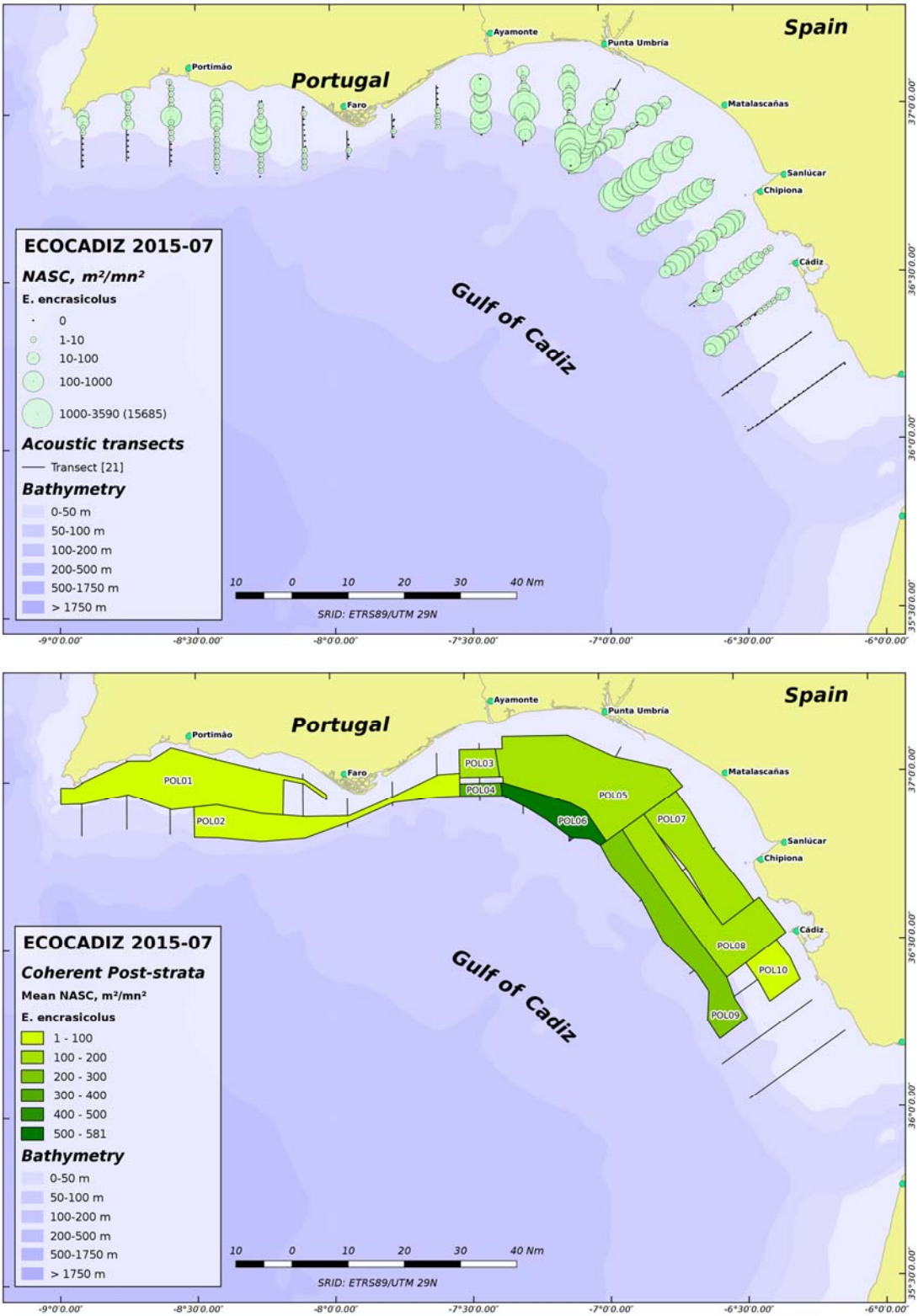


Figure 9. *ECOCADIZ 2015-07* survey. Anchovy (*Engraulis encrasicolus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species. Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

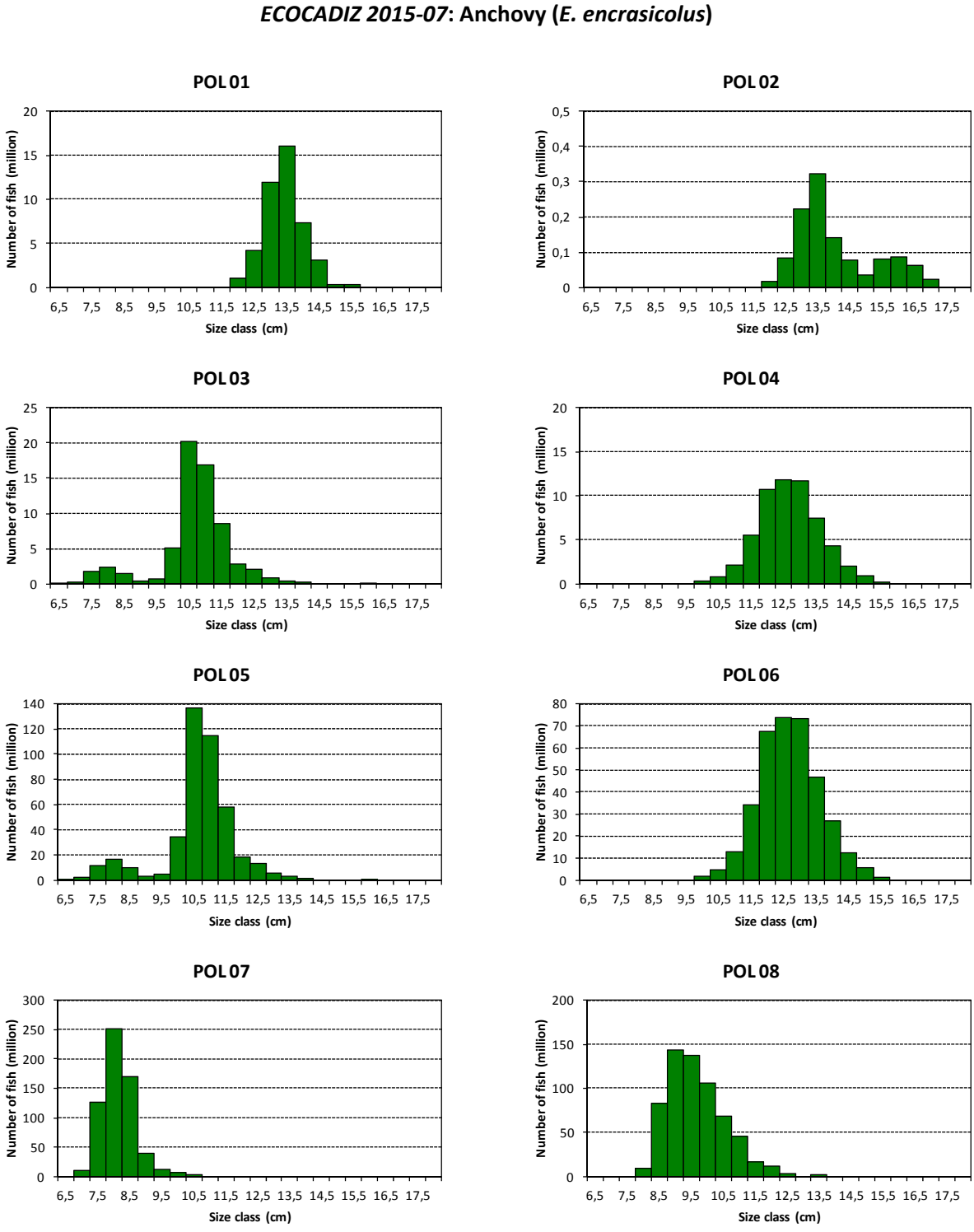


Figure 10. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 9**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

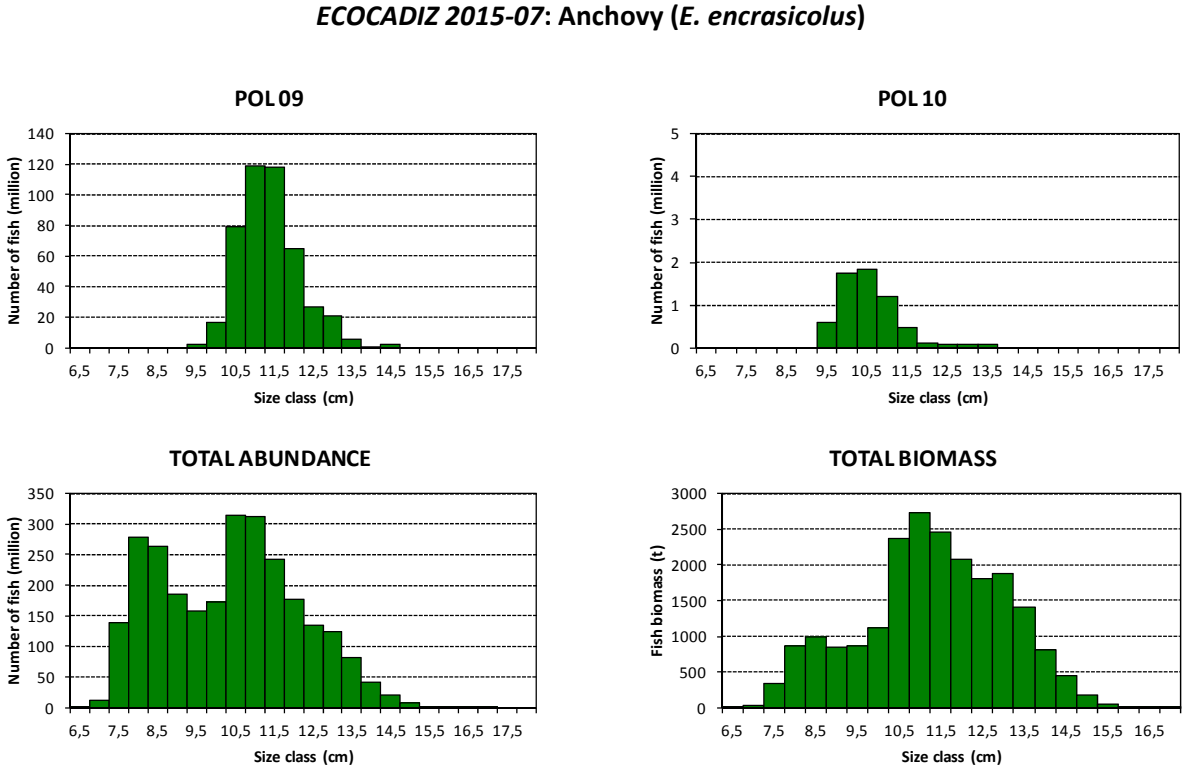
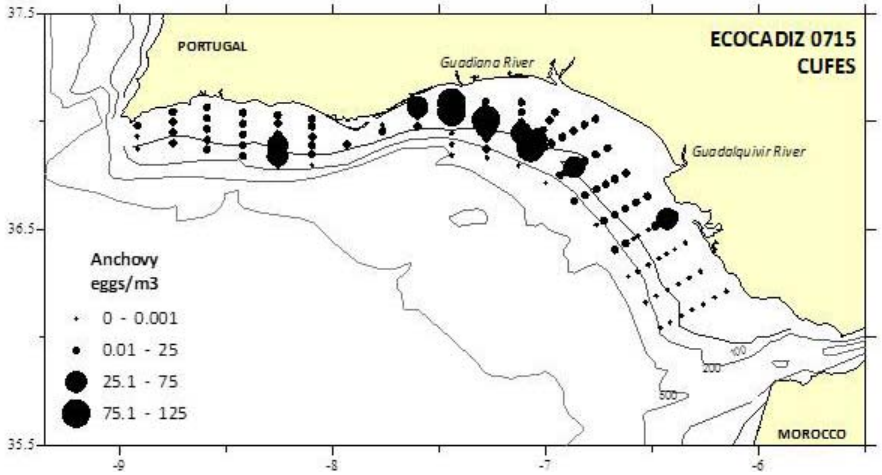


Figure 10. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Cont'd.



ECOCADIZ 2015-07 CUFES sampling		Spanish waters	Portuguese waters	Gulf of Cadiz
#Transects		11	10	21
#Stations		76	41	117
Anchovy eggs	# total	4640	3966	8606
	# max.	649	743	743
	Total density (eggs/m^3)	566.0	443.7	1009.7
	Max. density (eggs/m^3)	120.7	115.0	120.7
	Mean density (eggs/m^3)	7.5	10.8	8.6

Figure 11. *ECOCADIZ 2015-07* survey. Anchovy (*E. encrasicolus*). Distribution of anchovy egg densities as sampled by CUFES (eggs m^{-3}).

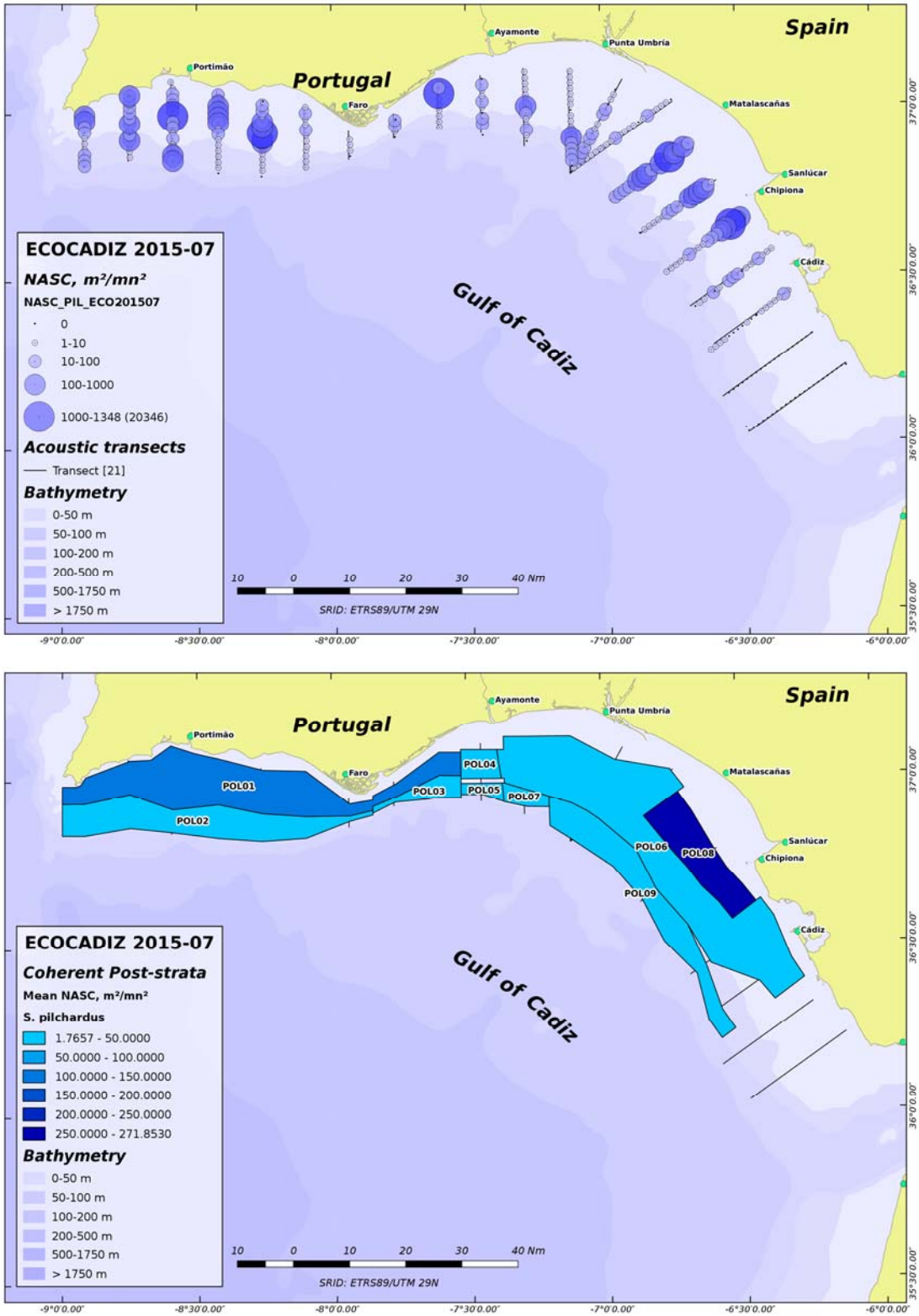


Figure 12. *ECOCADIZ 2015-07* survey. Sardine (*Sardina pilchardus*). Top: distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC,* in m^2 nmi^{-2}) attributed to the species Bottom: distribution of homogeneous size-based post-strata used in the biomass/abundance estimates. Colour scale according to the mean value of the backscattering energy attributed to the species in each stratum.

ECOCADIZ 2015-07: Sardine (*S. pilchardus*)

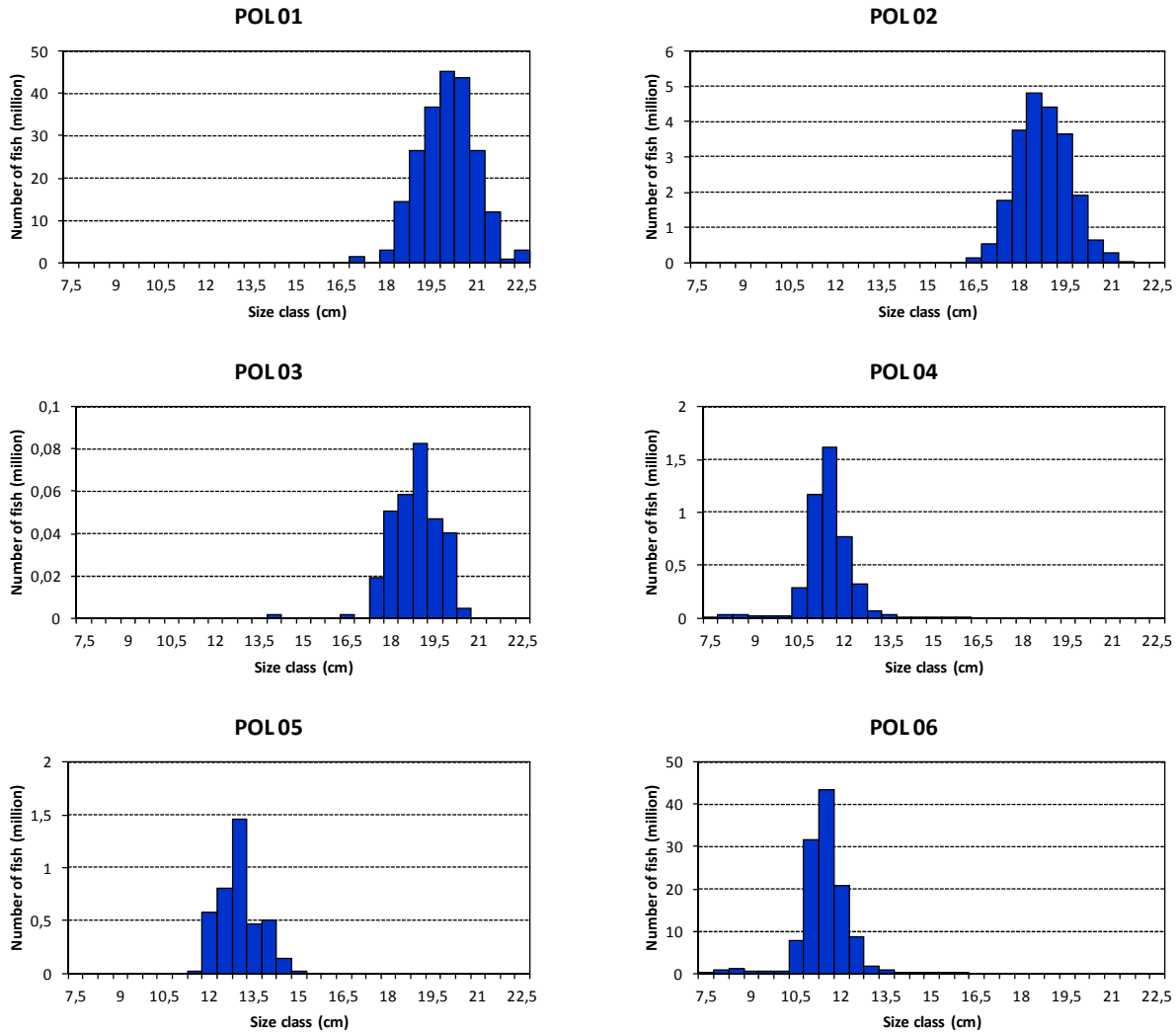


Figure 13. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Estimated abundances (number of fish in millions) by length class (cm) by homogeneous stratum (POL01-POLn, numeration as in **Figure 12**) and total sampled area. Post-strata ordered in the W-E direction. The estimated biomass (t) by size class for the whole sampled area is also shown for comparison. Note the different scales in the y axis.

ECOCADIZ 2015-07: Sardine (*S. pilchardus*)

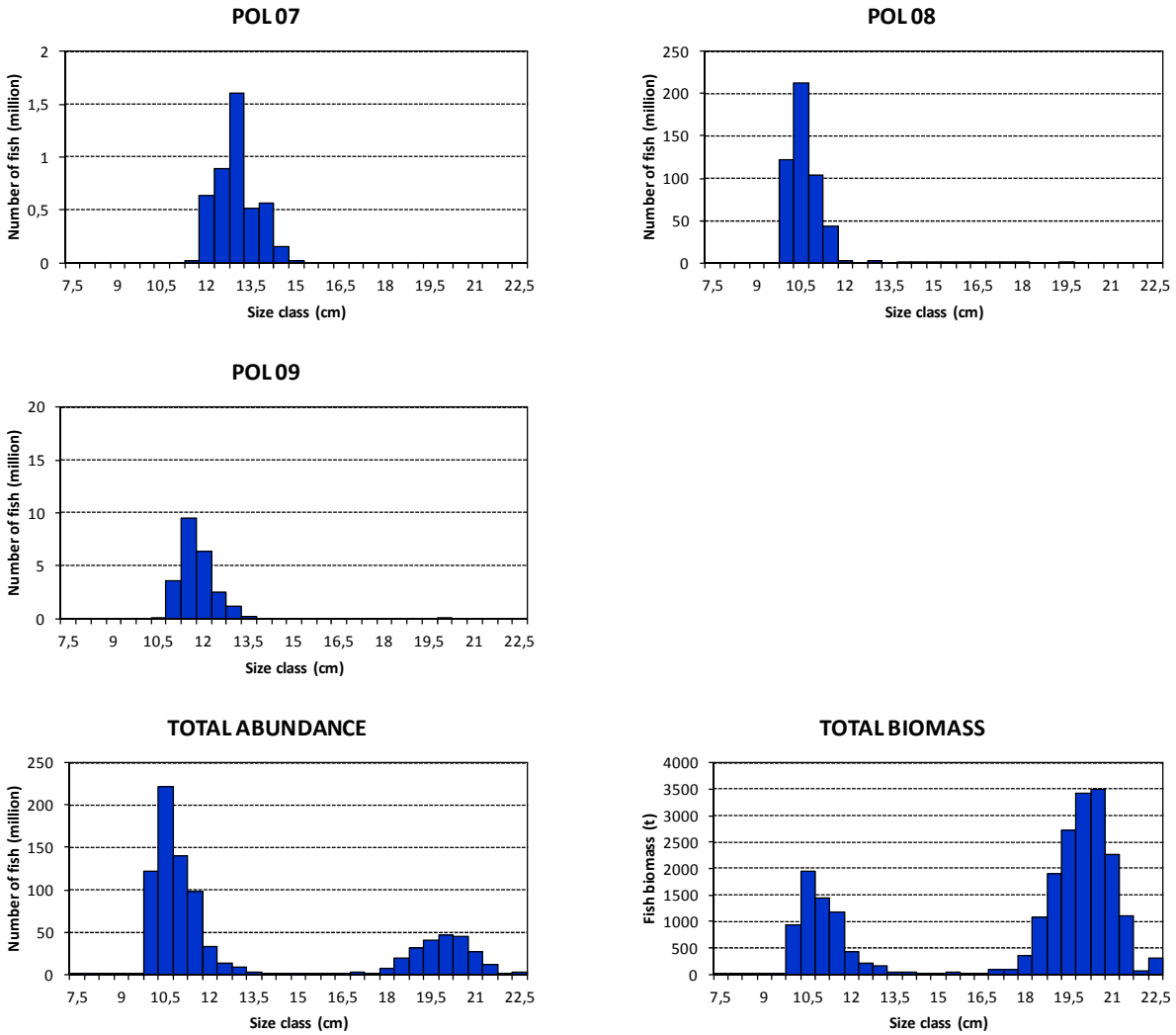


Figure 13. *ECOCADIZ 2015-07* survey. Sardine (*S. pilchardus*). Cont'd.

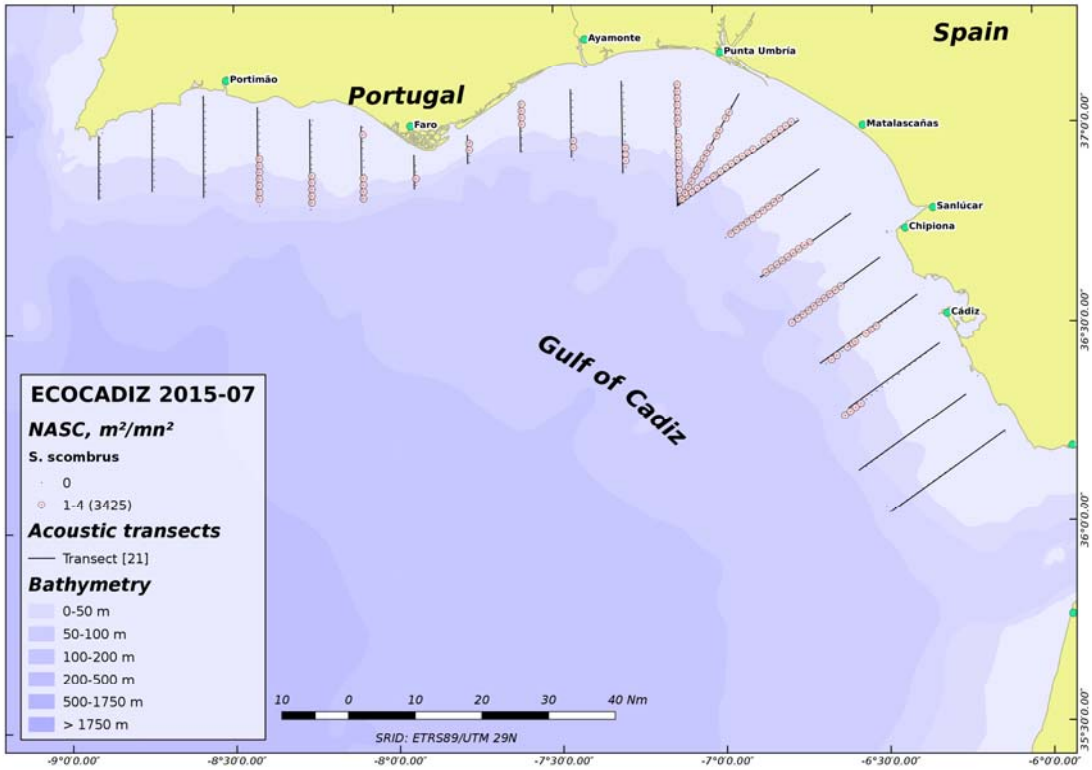


Figure 14. *ECOCADIZ 2015-07* survey. Mackerel (*Scomber scombrus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

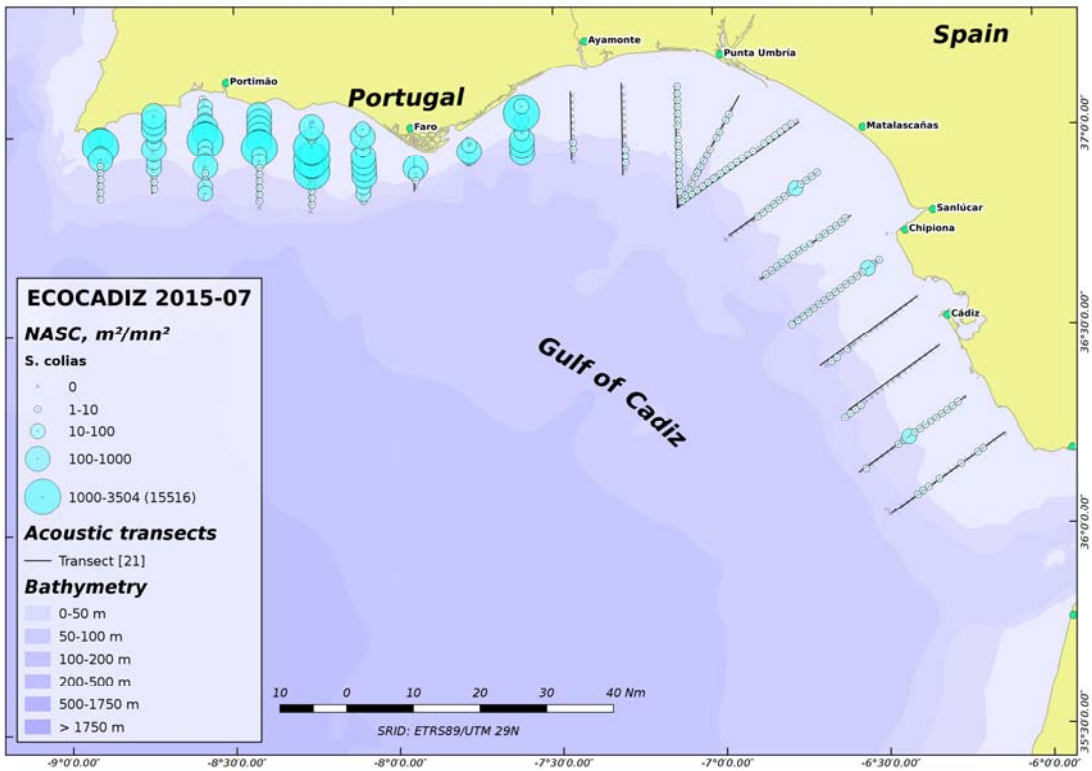


Figure 15. *ECOCADIZ 2015-07* survey. Chub mackerel (*Scomber colias*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

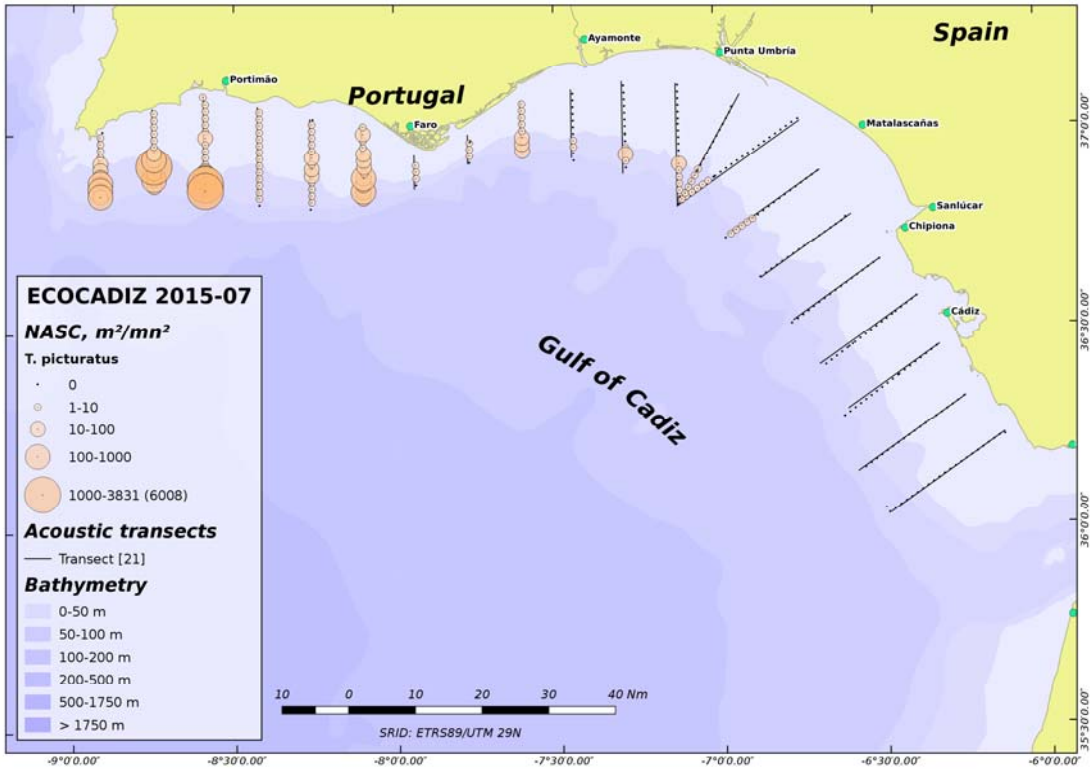


Figure 16. *ECOCADIZ 2015-07* survey. Blue jack mackerel (*Trachurus picturatus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

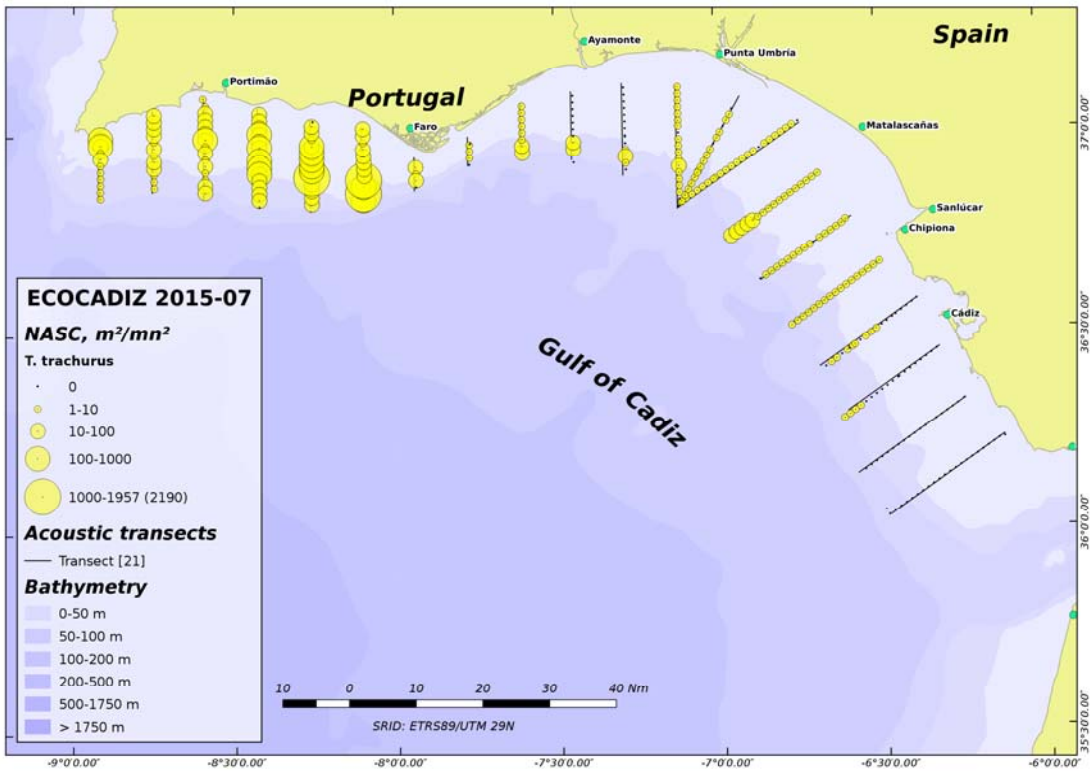


Figure 17. *ECOCADIZ 2015-07* survey. Horse mackerel (*Trachurus trachurus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

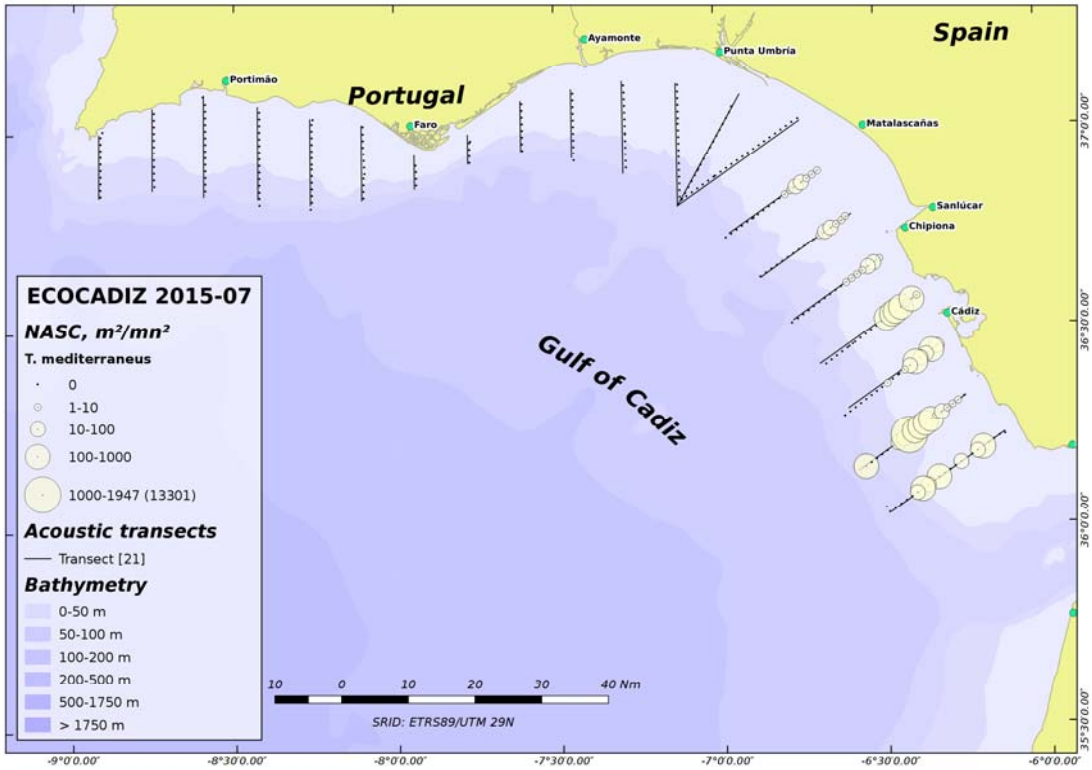


Figure 18. *ECOCADIZ 2015-07* survey. Mediterranean horse mackerel (*Trachurus mediterraneus*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

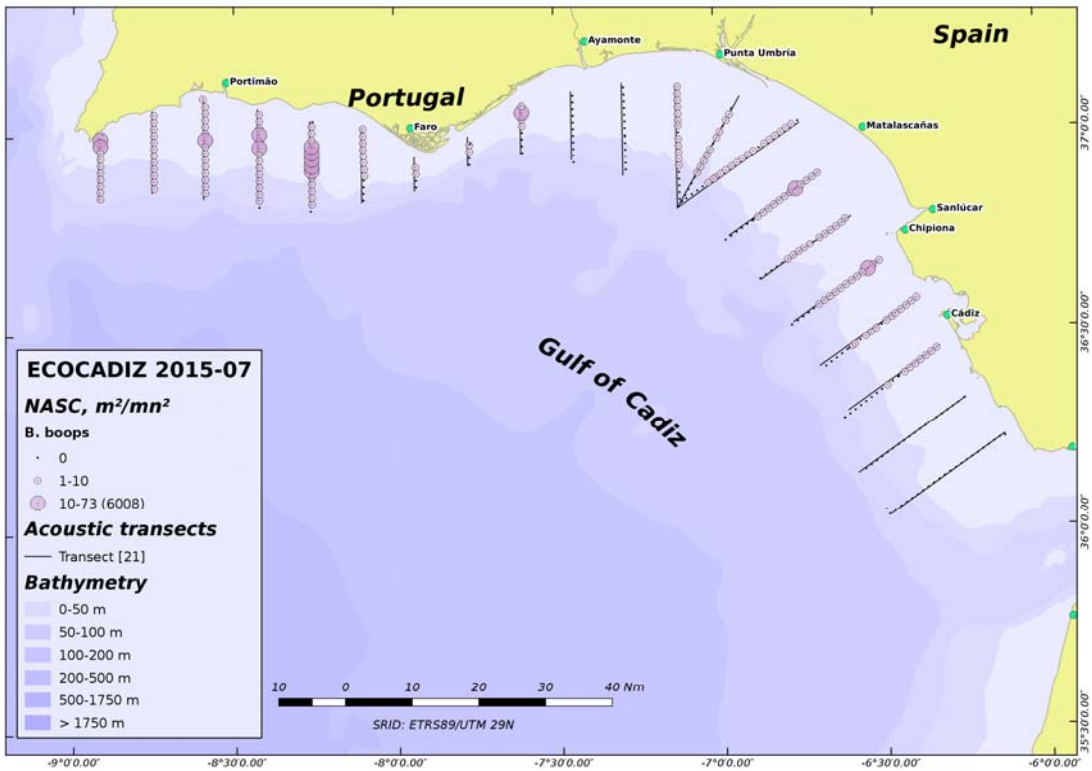


Figure 19. *ECOCADIZ 2015-07* survey. Bogue (*Boops boops*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

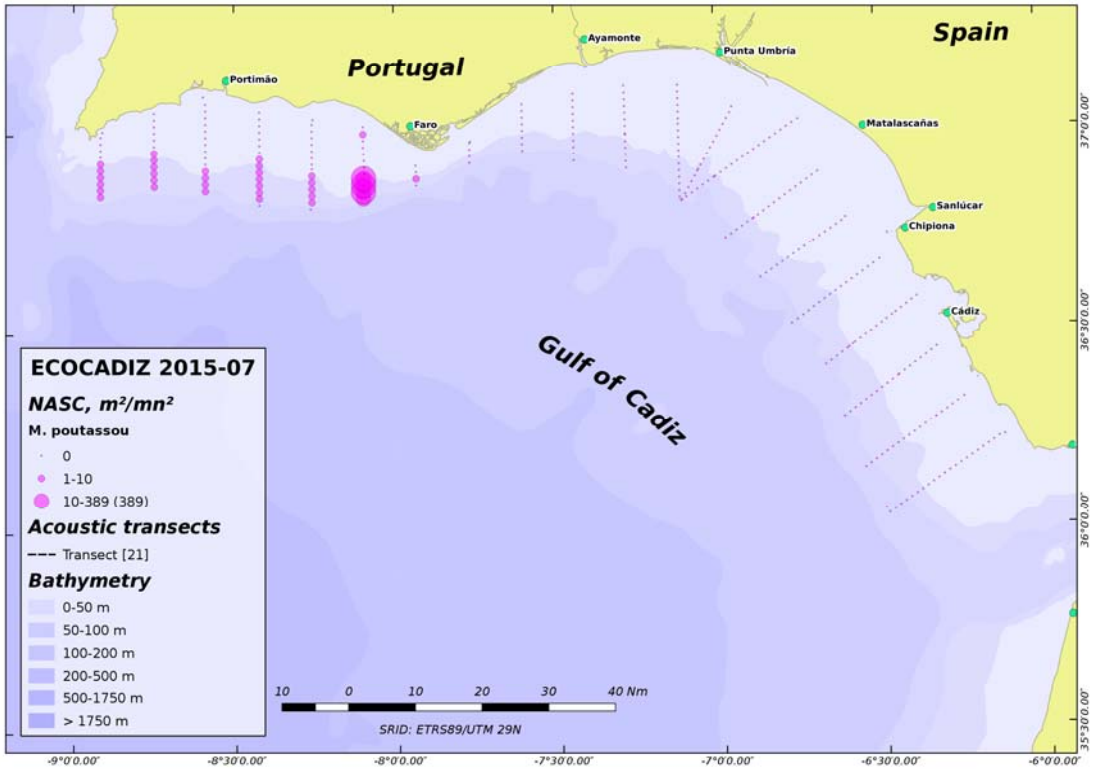


Figure 20. *ECOCADIZ 2015-07* survey. Blue whiting (*Micromesistius poutassou*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

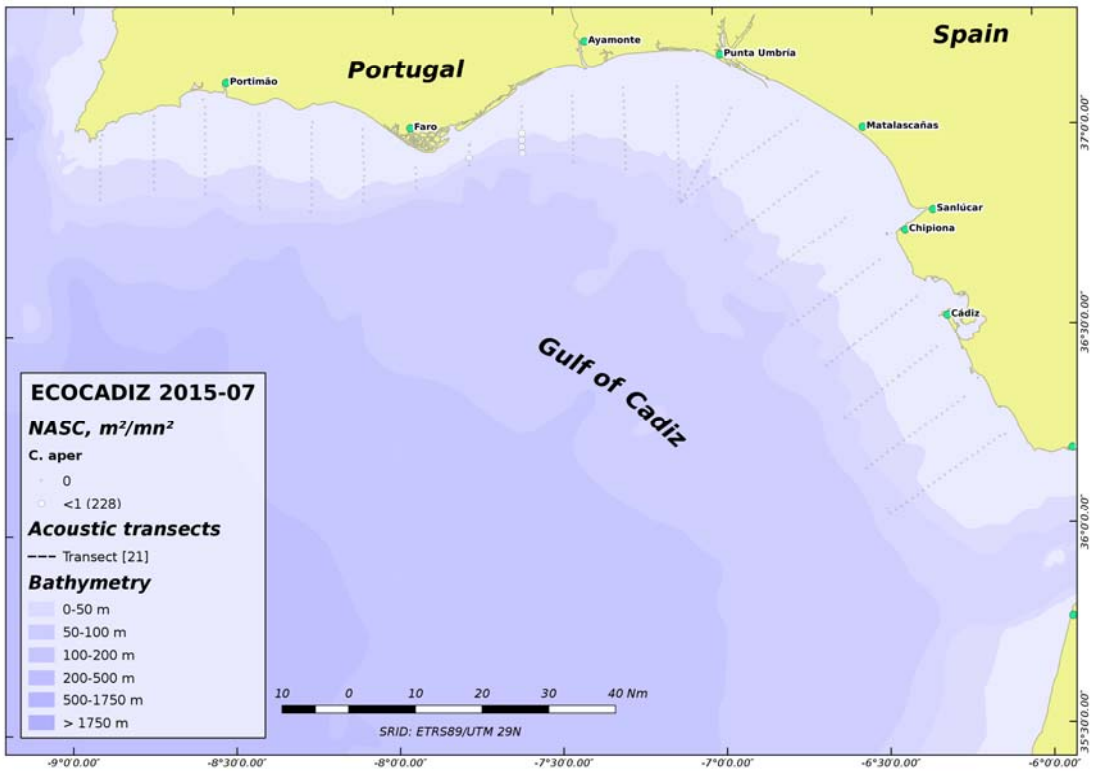


Figure 21. *ECOCADIZ 2015-07* survey. Boarfish (*Capros aper*). Distribution of the total backscattering energy (Nautical area scattering coefficient, *NASC*, in m^2 nmi^{-2}) attributed to the species.

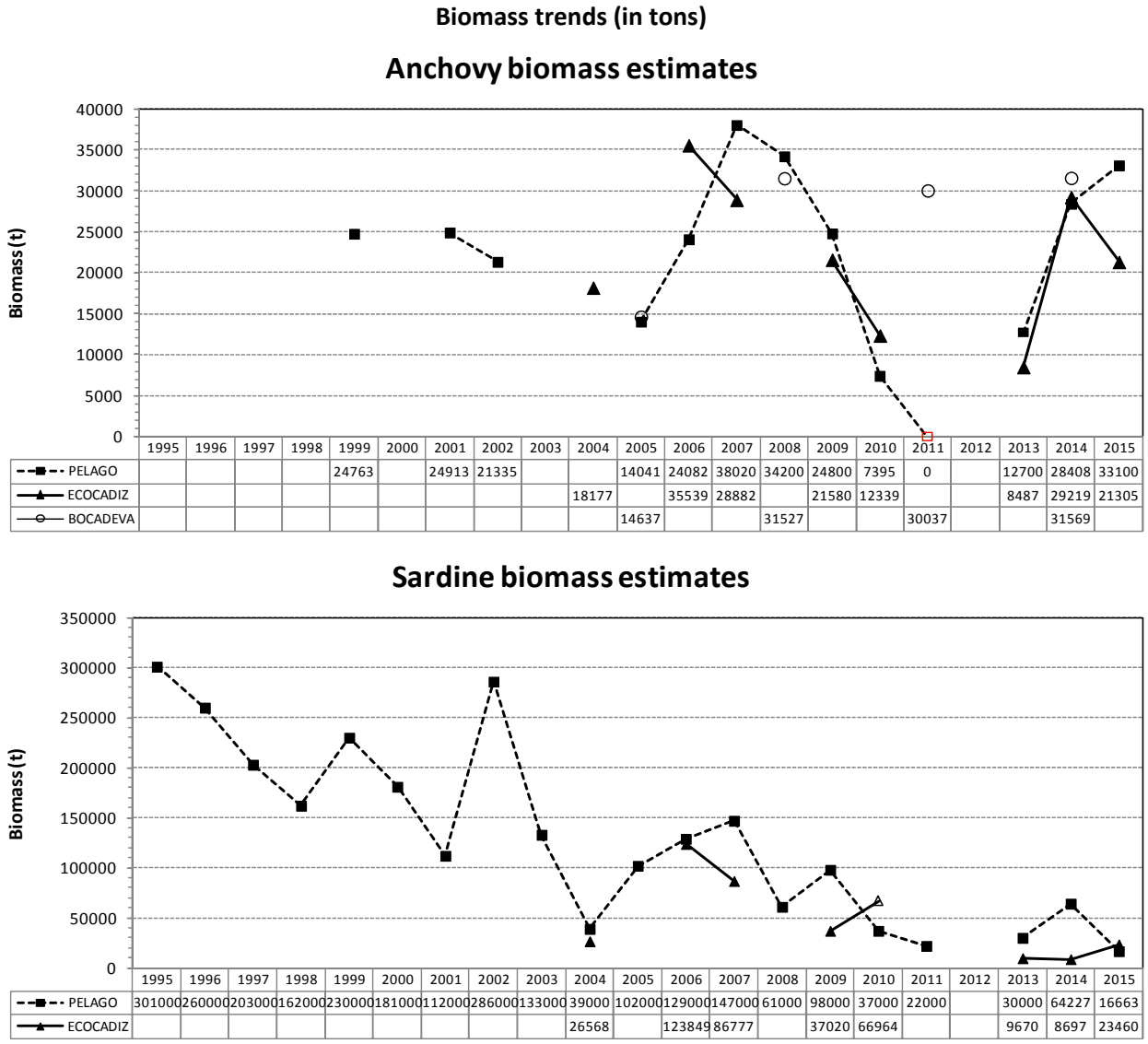


Figure 22. Trends in biomass estimates (in tons) for the main assessed species in Portuguese (*PELAGO*) and Spanish (*ECOCADIZ*) survey series. Gaps for the 2005, 2008 and 2011 anchovy acoustic estimates in the *ECOCADIZ* series are filled with the *BOCADEVA* Spanish egg survey estimates. Note that the *ECOCADIZ* survey in 2010 partially covered the whole study area. The anchovy null estimate in 2011 from the *PELAGO* survey should be considered with caution.